WORK PLAN

FOR WATERSHED PROTECTION AND FLOOD PREVENTION

BUFFALO CREEK WATERSHED

Guernsey and Noble Counties, Ohio

OUR SOIL ★ OUR STRENGTH

WATERSHED WORK PLAN

BUFFALO CREEK WATERSHED, OHIO

Guernsey and Noble Counties

OHIO

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act, (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by:

Buffalo Creek Subdistrict of Muskingum Watershed Conservancy District

Guernsey Soil and Water Conservation District

Noble Soil and Water Conservation District

Noble County Commissioners

Village of Sarahsville, Ohio

With Assistance by:

U. S. Department of Agriculture, Soil Conservation Service

U. S. Department of Agriculture, Forest Service

September 1964

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SUMMARY OF PLAN

The Buffalo Creek Watershed, consisting of 50.2 square miles (32,150 acres), is located in the north central part of Noble County and southern Guernsey County. Both Guernsey and Noble Counties are in the southeastern portion of Ohio.

Sponsors of this plan for watershed protection, flood prevention, and municipal water supply are the Guernsey and Noble Soil and Water Conservation Districts, the Noble County Board of Commissioners, the Village of Sarahsville, Ohio, and the Buffalo Creek Subdistrict of the Muskingum Watershed Conservancy District.

Devastating floods that cause extensive damage to rural lands, fences and buildings; to agricultural crops; and to such transportation facilities as roads, bridges and railroads occur frequently in this watershed. Between March 1963 and April 1964 three such floods struck this area. For example, the June 1963 flood resulted in an estimated $54,000 damage.

The planned works of improvement include two flood prevention impoundments, a multiple purpose flood prevention-municipal water supply reservoir, and 8.7 miles of channel enlargement. The recommended measures will be installed over a five year period.

When installed, this project will provide watershed protection by reducing soil loss, water runoff and sedimentation; reducing annual flood damages to agricultural lands, roads, bridges and railroads; and will provide water supply for the village of Sarahsville, Ohio, plus two separate school buildings belonging to the Noble Local School District. The water supply facility is planned to store 267 acre feet of water to meet the present and future needs of the Sarahsville community.

There are 124 farms in the watershed averaging 210 acres in size. Fifty one per cent, or 63 farms, have basic farm plans with the Guernsey and Noble Soil and Water Conservation Districts. Landowners and operators will install land treatment measures under agreement with their Soil and Water Conservation District. The estimated cost of this work is $308,914. Technical assistance will be provided by PL 566 funds amounting to $27,043.

The two single-purpose flood prevention structures, the multiple purpose flood prevention-municipal water supply reservoir, and the 8.7 miles of channel improvement will be installed through contracts administered by the Buffalo Creek Subdistrict of the Muskingum Watershed Conservancy District.

The structural works of improvement will reduce flooding on valley lands thereby directly benefiting 2034 acres involving approximately 75 rural properties. Nine miles of highway and one mile of railroad will have reduced flood damages.

The cost of all structural measures is $971,148. The PL 566 share is $719,225. The other than PL 566 share is $251,923. The other funds include: $45,642 water supply construction; $12,852 for installation services; $175,192 for lands, easements, and rights-of-way; and $18,237 for administration of contracts.

The Subdistrict will be responsible for the operation and maintenance of structural measures. Total annual cost of operation and maintenance of these measures is $4,420.

Annual benefits due to flood prevention, water supply and recreation amount to $44,225. Redevelopment and secondary benefits total $2,040 and $4,407 respectively. Structural measures as planned will return average annual benefits of $50,672. Annual costs amount to $36,234. The benefit cost ratio is 1.4:1.0.

DESCRIPTION OF THE WATERSHED

Physical Data:

General - The Buffalo Creek Watershed, comprising 32,150 acres or 50.2 square miles, is located in north central Noble County with a small portion extending into southwestern Guernsey County, Ohio. The watershed is roughly rectangular in shape with its axis running in a northwest - southeast direction.

Buffalo Creek flows in a northwesterly direction and joins Buffalo Fork to form Wills Creek at the western limits of Pleasant City. Wills Creek flows north and west to its junction with the Muskingum River at the Coshocton-Muskingum County line.

The topography is moderately steep throughout the watershed and has a difference in elevation of approximately 213 feet from the valley bottom to the divide on the southwest bounday. The highest elevations occur in the vicinity of the town of Mt. Ephraim near the northeast divide where a difference of 462 feet is found between this point and the stream valley at Pleasant City. The rugged upland topography results from geologic stream dissection in a moderately dense branching pattern.

The Buffalo Creek valley bisects the watershed lengthwise, and has three major tributaries: South Fork, Little Buffalo Creek, and North Fork entering the main stem from the northeast. One large tributary flows along U. S. Highway 21 from the south, and joins Buffalo Creek less than a mile south of Pleasant City.

The Buffalo Creek valley has a flood plain of 2,034 acres, is 1/4 mile wide at Sarahsville, and increases in width to 1/2 mile at the lower extreme of the watershed near Pleasant City. The stream gradient is such that a meandering stream pattern has developed which becomes increasingly intense from Sarahsville to Pleasant City. A few of the many isolated oxbows have been filled and cultivated. Some segments of the main stem have been cleaned at different times to improve local areas. The stream gradient ranges from 7.5 feet per mile at Sarahsville to 3.2 feet per mile at the lower end near Pleasant City.

Geology - The watershed lies geologically in the unglaciated Central Allegheny Plateau land resource area. The major part of the Buffalo Creek drainage basin is located in the weathered residual rocks of the Conemaugh formation of Pennsylvanian age. Remnants of the lower Monongahela formation, of the same age, cap the headwater uplands along the southern divide. The predominantly sandstone and shale strata contain some interbeds of limestone and recoverable coal. In several areas, principally near the southern and eastern divides, there are some active strip mine operations.

The Buffalo Creek valley is old, geologically. It contained a headwater tributary of the Cambridge River of the prehistoric Teays system, followed by Plainfield Creek of the Deep Stage system related to the Kansan glacial advance terminating to the north. This was followed by Kimbolton Creek of Post-Illinoian times, and finally the present Buffalo Creek. The effects of a complex fluvial and glacialogic history are evident in this now "buried" valley, 40' below the present surface, as reflected by the topographic terrace remnants, soils, ground water, and drainage aspects.

Soils - Most soils in the upland are complex in that they are weathered from interbedded residual rocks. Muskingum, Meigs, and Westmoreland are predominantly shallow soils occurring on the steep slopes. Rock outcrops are common in the steep valley sides and wooded ravines.

The bottomland soil profile exhibits the many facets of the prehistoric sedimentation, inundation, and erosion under the influence of large volumes of water from melting continental glaciers to the north. Erosional products from the immediate uplands during recent and modern times have produced soils in the Moshannon and Huntington series, some of which are moderately well to poorly drained. Reworked phases of these soils are also present. Isolated remnants of slackwater soils in the Holston series are also found, and some modification from the classic bottomland soil profiles exists in a complex pattern.

All bottomland soils are deep, fertile, and unstratified. They are mostly sandy and silty clays with residual rock fragments scattered sparcely through the profile. No transported glacial gravels are present.

Water Supply - The water supply is from common wells located in the 40 ft. prehistoric fill in the Buffalo Creek Valley. Water from the rock strata in the upland is scarce, and only low capacity wells are possible. Cisterns, springs, farm ponds, and streams are used for watering stock.

Climate[1/] - The watershed climate is moisttemperate. The mean annual precipitation is 39 inches based on a 25 year record at the Caldwell weather station.

The greatest amount of precipitation occurs in the months of May and June. The average annual snowfall is 26 inches.

The mean annual temperature is 54° F. with the mean maximum occurring in July and August. The mean minimum temperature in January is 29°.

The average date of the first killing frost in autumn is October 11th, and the date of the last killing frost in spring is May 8th. An average of 156 days comprise the frost-free season.

The prevailing winds are from the west.

Land Use and Cover Conditions - General-type farming is the predominant type of agriculture within the watershed. The upland is moderately steep which limits the cropland areas. Much of the upland is used for pasture and woodland. Approximately 25 per cent of the watershed is now in cropland, 35 per cent is in pasture, 25 per cent is in woodland, and 15 per cent is in other uses.

Approximately 40 per cent of the open land is in need of adequate conservation measures for protection against sheet erosion and run-off. The woodland, as reported by the U. S. Forest Service, is poor hydrologically due, principally, to a lack of proper management.

Economic Data:

General - The watershed is predominantly rural, and agriculture provides the major source of income. There is some strip mining of coal near the town of Pleasant City.

Off-farm work within the watershed is very limited, and many residents commute to their jobs in towns beyond its boundaries. Most are employed at the towns of Caldwell, Marrietta, Cambridge, and Zanesville which are located within a distance of 5 to 25 miles.

1/ U. S. Weather Bureau data compiled in Bulletin 15, Ohio Department of Natural Resources, Division of Water, and U. S. Weather Bureau data, Ohio Annual Summary.

Farm Data - The 1959 agricultural census shows that 84 per cent of the farms in the area are operated by owners, and 16 per cent by tenants. All watershed lands are privately owned except approximately 790 acres of public road rights-of-way and 40 acres owned by the Noble Local School District near the town of Sarahsville. Agricultural lands account for approximately 92 per cent of the total watershed area. There are about 124 farms in the watershed averaging 210 acres in size. Fifty-one per cent, or 63 farms, have basic farm plans with the Guernsey and Noble Soil and Water Conservation Districts. The average value of land and buildings in the watershed is estimated to be $65.00 per acre. The total population of the watershed is estimated to be 1,650.

The main source of income is from the sale of livestock and livestock products. The principal crops grown are: corn, oats and hay. Typical yields per acre are: corn-60 bushels; oats-40 bushels; and hay-2 tons.

Transportation Facilities - From Sarahsville to Pleasant City the Buffalo Creek channel is paralleled by State Route 146. Upstream from Sarahsville State Route 146 parallels the South Fork and State Route 147 parallels Buffalo Creek and Little Buffalo Creek. State Route 285 crosses Buffalo Creek and South Fork near Sarahsville. U. S. Route 21 and the Pennsylvania Railroad parallel the main channel near the western edge of Pleasant City. Construction plans are now being completed for Interstate Highway 77 which will cross the main valley approximately 2½ miles south of Pleasant City. Interchanges on Interstate Highway 77 are to be located 2 miles north of Pleasant City at State Route 313 and 5 miles west at Belle Valley. State Route 215 will soon be extended from Belle Valley to Sarahsville.

When completed Interstate Highway 77 will link the highly populated Cleveland, Akron, Canton, Youngstown areas with the south, and travel through this watershed will increase tremendously.

Population, Trends and Future Growth - The economic activity, measured by population trends, has declined steadily since the turn of the century. However, this decline has leveled off since 1950 due to the location of major industrial plants within commuting distance. Thus, the decline in agriculture and mining employment is now partly offset by manufacturing expansion in nearby areas.

The economic potential is promising in view of its mineral and human resources and geographic location. The project proposals will provide flood protection to the valley lands, village, roads and railroad along with added water for municipal and incidental recreation use.

WATERSHED PROBLEMS

Floodwater Damage:

Three noteworthy flood events occurred recently in Southeastern Ohio. The storms of March 4-5, 1963, June 4-5, 1963, and March 9-10, 1964, all caused severe flooding on Buffalo Creek. The June 1963

flood was the highest of record since 1937 at the Derwent and Cambridge water stage recorder gages, when flows were regulated by the Senecaville Reservoir. These gages are located on Wills Creek just downstream from the Buffalo Creek Watershed. The two March floods were similar in flood stages, but 0.5 to 1.5 feet lower than in June. All three floods are within the largest four of record at the gages.

In June 1963 rainfall averaged 4.0 inches over the Buffalo Creek basin in 15 hours with the highest concentration in the northern portion. The resultant flood, reported to have been the highest since the outstanding 1907 and 1913 floods, produced an average overbank stage of four feet while inundating 1,903 acres. The flood damage was estimated at $54,000. Extensive damage resulted to crops, pastures and transportation facilities.

The March 1963 rainfall, about 2.5 inches in 12 hours, on deeply frozen open ground, overflowed 1,773 acres of the flood plain to an average depth of 3 feet. The damage to fences, buildings, roads, and the railroad caused by this flood was estimated at $20,000.

The March 1964 flood was caused by 4.0 inches of rainfall in less than two days following a minor flood. The March 1964 flood, slightly higher than the previous March flood, again played havoc with private and public properties inundating about 1,800 acres. Damages were reported at $24,000.

Historically, floods of somewhat smaller magnitude have been experienced one or more times a year. The existing channel, although deep enough for drainage outlets, is clogged with vegetation and is incapable of handling the rapid runoff from the upstream watershed area. The meandering character of the stream results in overland flood flows causing prolonged inundation of the lands along the channel in all season of the year. Farmers have installed bedding systems in an attempt to move surface water to the existing channel rapidly after floods.

A total of 2,034 acres adjacent to the channel are directly affected by a 100 year frequency flood. Floods that occur during the summer growing season cause the greatest damage within the watershed.

Flood Frequency (Growing Season)	Acres Inundated
25 yr.	1,875
5 yr.	1,671
2 yr.	1,236

The average annual damage to crops is estimated to be $22,340. This damage results from flooding during the growing season and frequently occurs more than once a year on the main flood plain.

Other agricultural damages to farmsteads, fences, farm roads and bridges; livestock losses; and the extra cost of debris removal is estimated at $1,772 yearly.

The area flooded in and adjacent to Pleasant City includes five commercial and one small industrial establishments. An estimated six residences that could be affected by a large flood were not evaluated. The average annual damage to this urban area is estimated to be $490.

An estimated 9.02 miles of roads in the flood plain area are inundated by floodwaters. Much of State Route 146 that parallels the main channel is subject to flooding. Numerous other State and secondary roads that cross and parallel the valley have been damaged. The average annual floodwater damages to highways were estimated to be $2,314.

The Pennsylvania Railroad parallels the main channel for approximately one mile from Pleasant City southward to a point where it leaves the main valley and follows a tributary through the remaining portion of the watershed. An estimated one mile of the railroad is subject to flooding. Ballast washout and buckled rails caused directly by flooding have resulted in disrupted traffic, large repair costs, and loss of revenue. Saturation of the road bed also leads to pumping and deterioration of the ties and loosening of the rails. This causes high maintenance costs, much of which can be attributed to flooding. Average annual damages to the railroad by floodwater were estimated to be $1,336.

Erosion and Sediment Damage

Sheet and Gully Erosion - Aerial photos and field observation show that sheet erosion is generally moderate with occasional areas of severe erosion. Severe sheet erosion expected in strip mined spoil areas is limited in extent. Gullying in the upland is not common, however, some small partially stable gullies were observed. Gradual changes in land use, and the development of native cover in many areas have helped to reduce erosion in recent years. It was found that these types of erosion were not serious enough at present to warrant detailed studies.

Road bank erosion is active in some parts of the watershed. In determining sediment storage requirements for floodwater retarding structures consideration was given to this type of erosion. Many road banks have been eroded or cut back to the underlying rock within the watershed as a whole. Sloughing was observed in some areas above the rock but this is not considered extensive or serious enough to evaluate.

In the future, construction of Interstate Highway 77 across the extreme lower end of the watershed just above Pleasant City is contemplated. Induced erosion caused by this construction is considered minor within the watershed.

Improved land treatment measures and conservation practices are needed on the sloping farm lands for watershed protection.

Channel Erosion - Channel erosion is active within the cleared area along the main stem. In reaches of intensive meandering erosion is producing stream migration during high stages. This induces undercutting in the more friable upper soil horizons with consequent sloughing. It is anticipated this problem will be aleviated by the recommended channel improvement. Channel banks that are wooded are not eroding excessively.

Flood Plain Scour - The flood plain contains some shallow scour areas developed during overland flood flows. These areas, when they occur on cropland, are plowed in and farmed. The soils are deep and fertile, and no reduction in crop yields is reported by the farmers contacted. The scour areas are few in number, and in light of reports by farmers scour on the flood plain was not evaluated.

Sediment Damage - There are no significant areas of infertile overwash on the flood plain. Accumulations of bed materials are found as occasional shoals in the main stem particularly near the junctions of the tributaries. Considering the Buffalo Creek channel as a whole, the amounts of channel sediments were not considered a major problem, therefore no detailed studies were made.

Very limited strip mine areas are found at the extreme upper limits of the subwatersheds above structure sites No. 1 and No. 2. Infertile overwash from the spoils in these areas is limited to the perimeter of the spoils in wooded or idle land. No evidence of the transport of these materials or toxic waters to these sites have been observed, therefore no detailed studies were warranted.

Swamping resulting from natural levee or channel sediment deposits is not a problem in this watershed.

Problems Relating to Water Management:

Water Supply Problems - The residents of the Sarahsville community are presently serviced by individual water wells. The available water supply is limited in both quantity and quality. The deeper wells often have high contents of salt, iron and other minerals which greatly reduces the palatability of the water. Shallow wells have more palatable water, but are usually low producing. There are two schools in the community which have a need for more and better quality water.

Socio-economic Problems:

Both unemployment and underemployment are basic problems in the area. In many parts of the watershed, agriculture is marginal in nature. There are no industries located within the watershed. Many younger people that have been unable to find employment at home have migrated out of the area. Population growth has not kept pace with of the State or nation. Because of the employment situation the U.S. Department of Commerce has designated Guernsey and Noble Counties an Area Redevelopment Area.

Fish and Wildlife:

The population of such wildlife species as rabbit, squirrel, woodchuck, racoon and muskrat is relatively high within this watershed. Quail, grouse and waterfowl species are seldom found. The fish population consists of sunfish, suckers and bullheads none of which is found in abundance.

PROJECTS OF OTHER AGENCIES

There are no known County, State or Federal projects for water resource development which will affect or be affected by the works of improvement included in this plan.

BASIS FOR PROJECT FORMULATION

The sponsors requested that a plan for watershed protection and flood prevention be developed recommending works of improvement to reduce soil erosion; to prevent flood damage to agricultural lands and transportation facilities; to provide for water supply needs and to develop water-based recreation within the watershed.

In order to accomplish these objectives it was agreed by the sponsors that a combination of the following measures should be included in the plan:

1 - Land treatment measures to reduce soil erosion and sedimentation.

2 - Installation of floodwater retarding structures on major tributaries to store floodwater during periods of high runoff, and release it slowly over a period of time.

3 - Improve channels where needed to increase their carrying capacity and provide an economic level of flood protection.

4 - Incorporate extra water storage for water supply at one of the floodwater retarding structures near Sarahsville.

A 3 to 5-year minimum level of protection was considered an adequate criterion for flooded lands devoted to agricultural production. Buffalo Creek Watershed is essentially rectangularly shaped with the main channel running lengthwise along the western edge. The major tributaries contributing runoff in Noble County enter from the East. Most of the watershed cropland is located in the main channel flood plain which is considered to be some of the best potential agricultural land in the county. The policy to control as much drainage area as possible above the main damage area resulted in an original selection of 7 potential flood water retarding sites. All of these sites were located on tributaries above this main flood plain.

Careful analysis was made of the engineering, geologic, hydrologic and economic phases of each site. After due consideration of all the aspects involved, 3 sites controlling 37.3 per cent of the total watershed were selected. The floodwater retarding effect of the structures must be supplemented by channel improvement in order to achieve the level of flood protection desired by the sponsors.

A 5-year growing season channel capacity was determined to provide the maximum net benefits by restoring former productivity to the flooded lands devoted to agriculture. This will permit needed land use adjustments between cropped hill lands subject to erosion and the bottomlands.

The Village of Sarahsville has requested that additional water storage be added to floodwater retarding site No. 1. This will provide water supply for the village, two Noble Local District Schools and surrounding land owners.

The sponsors feel that a multiple purpose recreation development in the watershed is not feasible at this time due to the nearby locations of Senecaville Reservoir and the proposed Wolf Run Lake. The Senecaville Reservoir, operated by the Muskingum Watershed Conservancy District, is located about 8 miles northeast of Sarahsville. The 209 acre Wolf Run Lake, 4 miles west in the West Fork Duck Creek PL 566 watershed, will be operated by the Ohio Department of Natural Resources.

The sponsors are satisfied that the combination of works of improvement proposed in this plan will accomplish their objectives and provide an opportunity for economic growth in the area.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures:

The installation of land treatment measures to reduce erosion and sedimentation is an essential part of this plan. In the upland areas of the watershed, grasses and legumes will be increased in the rotations on cropland. Acreages of permanent pasture and woodland will also be increased. Pasture and hayland areas will be improved by renovating and increased by planting. In addition to agronomic changes in land use, mechanical practices such as contour strip cropping, diversion ditches, and grassed waterways will be installed on cropland in order to control erosion.

Since the flood plain contains practically all of the land suitable for intensive crop production in the watershed, some areas now in pasture or idle because of frequent flooding will be brought into econmic agricultural use by this project. Surface field ditches will need to be installed to carry surface water to outlet channels. Many of the existing bedding systems are unsuited for modern machinery operations and will be reconstructed as up-to-date surface drainage systems. Some areas will need systematic tile drainage to lower the water table below the root zone of the crops to improve plant growth. Diversion ditches must be used to divert hill runoff from the flood plain lands.

It is expected that changes brought about by the land treatment program will result in a slight decrease in total cropland in the watershed.

The land treatment program will increase soil fertility and productivity, improve soil structure, bring land use in line with the soils capability, reduce surface runoff and erosion.

The Soil Conservation Service will provide technical assistance for installing the above land treatment measures.

Land treatment measures for the woodland will include such practices as forestation, improved forestry practices, livestock exclusion, sustained yield and cultural practices. These measures will improve the forest hydrologic cover, soil conditions, water infiltration and retention, and thereby reduce storm flow. Technical assistance for the forestry measures will be furnished by the Ohio Department of Natural Resources, Division of Forestry, in cooperation with the U. S. Forest Service.

The total estimated cost of installing land treatment measures is $335,957 (PL 566 cost - $27,043, other than PL 566 cost - $308,914) as shown in Table 1.

Structural Measures:

General - A total of two single purpose flood prevention reservoirs and one multiple purpose flood prevention-water supply reservoir are planned for this watershed. In addition 8.7 miles of channel improvement are required for flood prevention.

Flood Detention and Water Supply Structures - All structures are designed to store the sediment accumulation for a 100-year period which is a total of 1,438 acre feet. The total floodwater detention capacity provided by the three structures is 2,057 acre feet. These structures control 18.74 square miles, or 37.3 per cent of the total watershed.

Structure No. 1, the multiple purpose structure, is planned to provide an adequate water supply for the Village of Sarahsville including the elementary and secondary schools located in the community. The present estimated populations of Sarahsville is 161 people and the enrollment in the schools includes 250 grade school pupils plus 350 high school students. Population growth has been projected and 155 acre feet of water with an additional allowance of 112 acre feet for evaporation losses is provided in this structure for water supply. In addition to water supply, the pool also contains a volume equivalent to a 100-year sediment accumulation from its drainage area. The surface area of the normal pool is 47 acres at elevation 895. In order to use the impounded water, a water supply intake structure with a discharge pipeline will be installed. The intake structure will be located within the impoundment and will consist of a tower with gated openings at key elevations to permit controlled entrance

of water from the impoundment. A pipeline will be laid from the base of the intake structure under the dam. This installation will permit controlled use of the stored water.

Structures No. 2 and 3, single purpose structures, are planned to provide flood protection in the flood plain downstream. A permanent water impoundment, hereafter termed the conservation pool, equivalent to an estimated 50-year sediment accumulation volume is provided at structures No. 2 and No. 3. This conservation pool will provide an estimated water surface area of 57 acres at structure No. 2 and 40 acres at structure No. 3.

Structure No. 1 is planned in series with Structure No. 2 in order to keep the floodwater detention volume at a desirable level below State Routes 146, 147 and the Shenandoah School located at this route junction. The detention volume for the uncontrolled area behind No. 2 is 2.04 inches and behind No. 3 is 2.09 inches.

The total estimated cost for installing the three structures is $585,708. The total annual cost is $19,967 of which $780 is for operation and maintenance.

The locations of the three sites are shown on the project map, Figure 2. A typical cross section of the earth fill and the concrete drop inlet is shown in Figure 1. Design data for the individual structures are given in Table 3 with costs in Tables 1 and 2.

Channel Improvement - Channel improvement for a distance of 8.76miles will supplement the three retarding structures to obtain the desired level of protection.

Channel improvement on the main stem of Buffalo Creek consisting of clearing, stream enlargement and straightening will extend from the confluence of Buffalo Creek and Buffalo Fork at Pleasant City upstream to a point at the confluence of Buffalo Creek and South Fork just downstream from Sarahsville, Ohio.

A seeded berm wide enough to permit maintenance operations along each bank is provided as part of this improvement. Generally the spoil will be spread. Openings will be left at intervals in the spoil to allow surface water to enter the channel.

The total cost of channel improvement is $385,440. The annual cost is $16,267 of which $3,640 is for operation and maintenance.

The location of all channel improvements is shown on the Project Map, Figure 2. Table 3-B, Channel Data, and Figure 3, Profile of Channel Improvement, show design details by reaches. The estimated cost of channel improvement is shown in Tables 1 and 2.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Costs:

The unit costs for installation of land treatment measures were based on current costs of farm labor, equipment and materials. The cost of technical assistance for the installation of land treatment measures was based upon Soil Conservation Service expenditures and Soil Conservation District accomplishments for the past several years. Costs for standard soil surveys are included in the technical assistance cost estimates.

The costs of forestry measures are based upon unit costs prevailing in the locality. The cost of technical assistance for installation of forestry measures is based upon costs of the going Cooperative Forest Management Program.

Structural Measures Costs:

Cost estimates for structural measures were derived by applying current unit costs to detailed material estimates. Unit costs were based on bid schedules of similar projects in Ohio and adjusted to the 1964 price level.

Construction costs were estimated by increasing estimated current contract costs by 12 to 17 per cent to cover contingencies. The per cent contingency was based on amount of available engineering data, type of design and geologic conditions of the area.

Installation Services include the cost of engineering (both design and construction) and related administrative services.

Land values for determining land easements and rights-of-way costs were estimated, taking into consideration land use, frequency of flooding, buildings affected, other improvements and current land values. Land costs at structure locations vary from $100 to $200 per acre. The cost of land used for fill sites, emergency spillways, borrow areas, channel relocation, and the cost of land placed permanently under water was estimated on the basis of fee-simple acquisition. An average cost for land that would be inundated for a temporary period was determined and applied to land behind structures. The value of any building affected was added to the land cost. Estimated costs of permanent right-of-way along channels vary from $100 to $200 while the costs of temporary construction rights-of-way range from $5 to $20 per acre. The cost of administration of contracts was estimated at 3 per cent of construction costs for structures and channels.

The following is a list of roads that will be affected by construction of the works of improvement and proposed alterations:

1. State Highway 147. Raise road in pool area above Structure No. 1.

2. State Highway 285. Reroute over top of fill of Structure No. 2.

3. County Road 44. Raise road in pool area behind Structure No. 3.

4. Township Road 119. Replace twin arch culverts with a structure of greater capacity at Station 505+50 channel improvement.

The above alteration items are included as easement and right-of-way costs. The top width of Structure No. 2 will be increased in order to reroute State Route 285 across the top of the dam, at a non-project cost of $11,083.

Flood prevention-water supply Structure Site No. 1 is estimated to cost $173,361 including $21,400 for water supply appurtenances. The PL 566 share amounts to $78,047 and includes 100 per cent of the construction and installation services costs for flood prevention. The remaining $95,314, which is other than PL 566 costs, includes construction and installation service costs for water supply and all costs pertaining to land rights and administration of contracts.

Following is the estimated obligation of total project funds including land treatment and structural measures for each fiscal year during the installation period.

	PL - 566		Other Than PL - 566	
Fiscal Year	Land Treatment (Dollar)	Structural Measures (Dollar)	Land Treatment (Dollar)	Structural Measures (Dollar)
First	3,250	86,317	37,070	127,620
Second	7,300	108,489	83,410	106,505
Third	8,925	206,505	101,940	13,583
Fourth	5,410	160,503	61,780	2,328
Fifth	2,158	157,411	24,714	1,887
	27,043	719,225	308,914	251,923

Allocation of cost to purpose is shown in the Economic Investigation section of this plan. Cost tabulation may be found in Tables 1, 2 and 4.

EFFECTS OF WORKS OF IMPROVEMENT

The installation of both the land treatment and structural measures recommended in this plan will fulfill the sponsors objective for flood prevention and water supply, and will produce the benefits described in this work plan.

Flood Prevention:

The Buffalo Creek Watershed project will provide essentially a 5-year economic level of protection to agricultural flood plain areas of the watershed. The areas on tributaries below floodwater retarding structures will benefit by a higher level of protection, 25 to 50 years. On the main channel from Sarahsville to about the SR #146 crossing in Noble County (1½ miles south of Pleasant City), the improved channel capacity will provide a 5-year growing season level of protection. The lower reach, above Pleasant City in Guernsey County, which is affected by back water from Wills Creek, will be provided an average 2-year level of protection by the project.

With project installation, the runoff from flood producing storms will be trapped in the floodwater storage basins provided behind the structures, and will be released through conduits at controlled rates that can be handled safely within their downstream channels. In addition, the water carrying capacity of the channel will be increased so that overbank stages will be less for the same storm magnitude. The effect of the project on other-size floods is tabulated below:

Flood Frequency (Growing Season)	Acres Flooded: With Project	Acres Flooded: Without Project	Percent Reduction of Acres	Av. Stage Reduction (foot)
2 yr.	185 1/	1,236	85%	3
5 yr.	614 1/	1,671	63%	2
25 yr.	1,451	1,875	23%	1½

The structural measures, in providing this level of flood protection to agricultural lands, will reduce the average annual agricultural damages by 77 per cent.

In the total 2,034 acres benefited, which were subject to or affected by overflow from the 100-year flood, there are approximately 400 beneficiaries.

Although not an objective of the project the works of improvement will have some effect in reducing the flooding in the urban area (villages of Pleasant City and Fairview) at the confluence of Buffalo Creek and Buffalo Fork.

The project also provides flood protection to transportation facilities and utilities. Approximately 9 miles of highways and 1 mile of railroad bed in the watershed are benefited by the reduction in floodwater stages. The average annual damage will be reduced 44 per cent to the railroad and 81 per cent to highways.

Future bridge replacement may be made with structures of reduced size consequent to the retarding effect of the flood prevention structures on peak flows.

1/ Majority of these acres are in the reach immediately above Pleasant City. This reach is affected by backwater conditions from Wills Creek.

With the 5-year level of protection provided flood plain lands, it is expected that more intensive agricultural use will occur. About 64 per cent of the flood plain in now in cropland. More intensive use and changed land use benefits are anticipated on 848 acres. An estimated 227 acres will be restored to their former productivity.

Project effects on flood stages for both the 5-year and the 100-year flood frequency is shown in Figure 4.

Water Supply:

The Sarahsville Village Council has requested that 155 acre feet of water supply storage plus additional storage necessary for evaporation losses or a total volume of 267 acre feet be included in the reservoir of structure No. 1. This development will make water available for home and public school use to the 761 residents and pupils of the Sarahsville Community. It is estimated that the 267 acre feet will provide a safe water yield of 140,000 gallons per day for 1,400 people.

Recreation:

Site No. 1, a multiple purpose flood prevention-water supply reservoir, and single purpose flood prevention sites No. 2 and 3 will provide 125 surface acres of conservation pool area which will be utilized for incidental recreation. All are adjacent to or crossed by County and State highways and will be readily accessible to the general public. The pool at site No. 2 is adjacent to the Shenandoah High School grounds. Public access will be provided at the three pools. They are estimated to provide 17,500 visitor days. The peak monthly use is expected during the months of June, July and August with peak use occuring on weekends and holidays.

Fish and Wildlife:

The channel improvement which is planned for this watershed will not impair fishing, since fish populations do not consist of game species, nor will it harm game populations, since there is much brushy cover in the area already. The increase in grass and crop habitat will provide some needed food and cover for the farm game species. The wildlife habitat will be further improved if some of the oxbows created by the stream straightening are maintained as wildlife areas in the bottoms. The land treatment program, farm ponds, protected odd areas, grass-legume and crop areas will benefit the wildlife habitat for farm game since these types of cover are generally scarce in the area.

PROJECT BENEFITS

Installation of structural works of improvement recommended in this work plan will produce average annual monetary benefits of $50,672. It is anticipated that these benefits will result from the

reduction of flood damage to agricultural land, populated areas and transportation facilities; enhancement of agricultural lands; reduction in the future design capacity of bridges; water storage for municipal use; incidental recreational use of conservation pool areas; reduced soil erosion; and improved local economic conditions.

Benefits accruing from the reduction of damage to crop and pasture lands are estimated at $17,283 and to the restoration of former productivity at $3,063 annually. Those attributable to a reduction in other agricultural damages including farm roads, bridges, fences, culverts, and debris removal amount to $789.

A substantial portion of farming operations in the area now subject to flooding reflects the risks of farming such lands. It is anticipated that improved cropping methods and land use conversion will occur where flood reductions are significant. Benefits of $8,107 will accrue on 805 acres of the more frequently flooded acres that will be protected by the planned works of improvement installed.

Average annual benefits of $2,577 are anticipated from floodwater damage reduction to transportation facilities. The transportation benefits include $1,951 annually from roads and bridges, and $626 annually from railroads.

The reduction in damage to the urban area on the western edge of Pleasant City will result in an annual benefit of $193.

Indirect benefits amount to $2,285 or 10 per cent of the direct benefits.

The permanent water supply storage, provided at structure No. 1 for the Sarahsville community, will provide annual benefits estimated at $2,334.

The incidental recreation benefits were based on a per unit visitor-day value of $0.50. The estimated 17,500 visitor-days provide annual benefits of $7,961. The conservation pools at the three structure sites are accessible to the general public.

Redevelopment benefits stemming from project installation as a result of the employment of the unemployed and underemployed are evaluated at $2,040. Benefits attributable to the cost of operation and maintenance of the structural improvements are estimated to be $161.

Benefits accruing because of a reduction in bridge replacement costs are estimated to be $554.

Local seconday benefits stemming from the project were considered to be equal to 10 per cent of the direct primary project benefits and were computed at $4,407. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

The installation of this project would have reduced the floodwater damage caused by three major floods experienced in this watershed in March and June, 1963 and March 1964. The March and June, 1963, flood damage would have been reduced by $10,000 and $23,000 respectively (50 and 43 per cent reduction). The March, 1964, flood damage would have been reduced 46 per cent with an estimated benefit of $11,000.

COMPARISON OF BENEFITS AND COSTS

The total estimated structural installation costs (Table 2) when amortized over the evaluation periods, as shown in Table 4, give an average annual equivalent cost of $31,814. The average annual cost of operation and maintenance of structural works of improvement is estimated at $4,420. The total annual cost is $36,234 (Table 4). When the project is completed and operating, the estimated average annual benefits from structural measures will be $50,672.

The ratio of the total annual benefit, without the inclusion of $4,407 local secondary benefits, to the total annual cost is 1.3:1.0. The ratio of the annual benefit including local secondary benefits, to the total annual cost is 1.4:1.0.

PROJECT INSTALLATION

The period of time necessary to install all land treatment and structural measures shown in Table 1 is estimated to be 5 years.

In order to accomplish construction with a minimum amount of danger, delay and inconvenience the following items should be used as a guide in determining the sequence of events:

1. Structure No. 2 is designed with Structure No. 1 in place.
2. Channel improvement is designed with structures in place.

Using these rules the following sequence of installation is recommended:

Fiscal Year	Structural Measures
1	Floodwater Retarding Structure No. 3
2	Multiple Purpose Structure No. 1
3	Floodwater Retarding Structure No. 2
4	Channel Improvement - Main Stem - Sta. 764+10 to 488+40
5	Channel Improvement - Main Stem - Sta. 488+40 to 306+70

Prior to initiating construction on any single structure, the sponsoring organizations will agree to use all the powers at their command to secure the necessary land easements and rights-of-way for all structural measures. The Buffalo Creek Subdistrict of the Muskingum Watershed Conservancy District has the power of eminent domain to acquire necessary lands, to raise needed funds, to enter

into contracts to construct works of improvement, and to maintain such works. All powers and facilities vested in the Subdistrict by law will be used as needed to complete the project.

It will be the duty of the Subdistrict to secure all land, easements and rights-of-ways for construction and maintenance of all structural works of improvement, and to be responsible for construction and administering contracts of all structural measures. Other sponsoring local organizations will assist the Subdistrict where practical.

The Village of Sarahsville, Ohio will enter into agreement with the Buffalo Creek Subdistrict of the Muskingum Watershed Conservancy District for the inclusion of water supply storage at multiple purpose flood prevention-municipal water supply Structure No. 1. The Village will cooperate with the District to secure land, easements and rights-of-way for construction of this reservoir.

The Soil Conservation Service will assist the sponsoring organizations in developing engineering plans and specifications, in preparing contracts for construction and will provide construction inspection for installation of structural measures.

The officials of Noble County and the Ohio Department of Highways will coordinate their respective road and bridge work with the construction schedule of the Conservancy District.

Land treatment measures will be applied by the landowners in cooperation with Noble Soil and Water Conservation District. Technical assistance on open lands will be provided by the Soil Conservation Service. Financial assistance will be provided for the installation of land treatment measures from the Agricultural Conservation Program, with educational assistance from the Extension Service.

Table 1 shows the amount of land needing treatment and the cost of technical assistance for forestry to be furnished by the Ohio Department of Natural Resources, Division of Forestry, in cooperation with the U. S. Forest Service. The technical assistance for installing the forestry measures will cost $8,640. This includes the going Cooperative Forest Management Program costing $760 and accelerated technical assistance costing $7,880. The accelerated technical assistance costs consist of $4,050 under authority of PL 566 which will be matched with $3,830 from the Ohio Department of Natural Resources, Division of Forestry.

FINANCING PROJECT INSTALLATION

The Noble Soil and Water Conservation District will encourage accelerated installation of the land treatment measures contained in this plan. The estimated total cost of installing land treatment measures is $335,957. The cost to the landowners is estimated at $308,914. Part of this cost may be shared through the Agricultural Conservation Program or paid from other going programs.

The present level of technical assistance will be supplemented by PL 566 funds so that needed land treatment measures can be planned and applied during the installation period. Accelerated technical assistance to be provided by PL 566 funds is $27,043. Table 1 shows the area of land needing treatment and the cost of technical assistance for forestry to be furnished by the Ohio Department of Natural Resources, Division of Forestry. In addition, the Ohio Department of Natural Resources, Division of Forestry will provide $760 for technical assistance under the "going" program. It is expected that the Agricultural Conservation Program cost-sharing will be available to qualified landowners for installing forest land treatment measures.

The Buffalo Creek Subdistrict of the Muskingum Watershed Conservancy District will be financially responsible for the local share of the costs involved in constructing and maintaining all structural works of improvement. Funds for which the Subdistrict is obligated may be raised by assessments to benefited properties under authority of the Ohio Revised Code covering the Conservancy District, or by other means. The Village Council of Sarahsville has made application to the Farmers Home Administration for a loan, as provided in the act, to finance the water supply portion of the project.

The total cost of all structural measures to be paid by "Other" funds is estimated to be $251,923, as shown in Table 2.

When legal requirements have been met, the Soil Conservation Service will make available an estimated $545,934 of PL 566 funds. These funds will be furnished as needed and as they become available. An estimated $173,291 of PL 566 funds for installation services will be utilized by the Soil Conservation Service as shown in Table 2.

Federal assistance for carrying out works of improvement on non-federal land as described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (PL 566-83d Congress; 68 Stat. 666) as amended.

PROVISIONS FOR OPERATIONS AND MAINTENANCE

Land treatment measures for watershed protection on privately owned land will be installed, operated and maintained by land owners, under cooperative agreements with their Soil and Water Conservation District. Technical assistance of the Soil Conservation Service will be provided upon request by the land owners and operators to determine maintenance needs and to encourage them to perform the needed maintenance. After completion of the PL 566 project, forestry program measures will be maintained by landowners and operators with technical assistance provided by the Ohio Department of Natural Resources, Division of Forestry, in cooperation with the U. S. Forest Service, under the going Cooperative Forest Management Program.

Operation and maintenance agreements will be executed for all structural measures prior to issuing the invitation to bid on construction contracts. These agreements will be made between the Soil Conservation Service and the Subdistrict. The Subdistrict will

assume responsibility for operation and maintenance immediately upon acceptance of construction from the contractors. Funds needed for maintenance will be raised by the Subdistrict through normal legal procedures, or by other means.

The Subdistrict will enter into an agreement with the Village of Sarahsville providing for the operation and maintenance of the water supply portion of the multiple purpose reservoir (Structure No. 1). The Village of Sarhsville plans to provide water to the Noble Local School District as well as to its residents and surrounding landowners.

Inspection of the individual structures and channels will be made annually and following major storms. The inspection will be made by a committee composed of representatives of the sponsoring organizations, the Soil Conservation Service, and other local County, State or Federal agencies. Aurthorized representatives will have free access to inspect structural works of improvement.

Items of inspection will include, but not be limited to, the condition and proper functioning of the concrete work, earth fills, principal and emergency spillways, vegetative growth, channel banks, capacities and appurtenances, bridge abutments, and accumulation of sediment and debris.

Reports will be prepared after the inspection stating maintenance needed. The reports together with a record of the action taken will be kept on file by the Conservancy District.

Vegetative growth in the channels and on the berms will be controlled largely by a mowing program. Some spraying may also be necessary.

All private bridges and facilities of public utilities will be maintained by the respective owners. All other bridge maintenance will be handled by officials responsible for such maintenance from funds, appropriated for that purpose.

Operation and maintenance for the structural works of improvement in this plan may be accomplished either by contract or by force account. The total annual operation and maintenance cost is estimated to be $4,420 of which $780 is for structures and $3,640 is for channels.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Buffalo Creek Watershed, Ohio

Sheet 1 of 2

Installation Cost Item	Acres to be Treated 2/	Estimated Cost (Dollars) 1/ P.L. 566	Other	Total
LAND TREATMENT				
Soil Conservation Service				
Cropland	8,038		99,375	99,375
Grassland	11,574		161,510	161,510
Miscellaneous Land	3,858		14,660	14,660
Technical Assistance		22,993	15,379	38,372
SCS Subtotal		22,993	290,924	313,917
Forest Service				
Woodland	3,680		13,400	13,400
Technical Assistance		4,050	4,590	8,640
FS Subtotal		4,050	17,990	22,040
TOTAL LAND TREATMENT		27,043	308,914	335,957

1/ Price Base 1964

2/ Non-Federal Land

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TABLE 1 - ESTIMATED PROJECT INSTALLATION COSTS

Buffalo Creek Watershed, Ohio

Sheet 2 of 2

Installation Cost Item	Unit	Number 2/	Estimated Cost (Dollars) 1/ P.L. 566	Other	Total
STRUCTURAL MEASURES					
Floodwater Retarding Structures		2	224,343		224,343
Stream Channel Improvement	Mi.	8.7	262,909		262,909
Multiple Purpose Structure		1	58,682	45,642	104,324
Subtotal - Construction			545,934	45,642	591,576
INSTALLATION SERVICES					
Engineering			135,699	12,852	148,551
Other			37,592		37,592
Subtotal - Installation Services			173,291	12,852	186,143
OTHER COSTS					
Land, Easements & R/W				175,192	175,192
Administration of Contracts				18,237	18,237
Subtotal - Other				193,429	193,429
TOTAL STRUCTURAL MEASURES			719,225	251,923	971,148
TOTAL PROJECT			746,268	560,837	1,307,105
SUMMARY					
Subtotal S.C.S.			742,218	542,847	1,285,065
Subtotal F. S.			4,050	17,990	22,040
TOTAL PROJECT			746,268	560,837	1,307,105

1/ Price Base 1964

2/ Non-Federal Land

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT 1/

Buffalo Creek Watershed, Ohio

Measures	Unit	Applied to Date	Total Cost (Dollars) 2/
LAND TREATMENT			
Conservation Cropping System	Ac.	930	930
Cover & Green Manure Crop	Ac.	111	500
Diversion	Ft.	7,418	1,484
Drainage, Field Ditch	Ft.	43,528	13,058
Drainage, Main or Lateral	Ft.	10,268	8,214
Farm Pond	No.	17	14,450
Grade Stabilization Structure	No.	4	800
Grassed Waterway or Outlet	Ac.	.25	75
Hedgerow Planting	Ft.	4,125	248
Pasture & Hayland Planting	Ac.	502	35,140
Pasture & Hayland Renovation	Ac.	743	29,720
Spring Development	No.	49	13,475
Strip Cropping, Contour	Ac.	501	5,010
Tile Drain	Ft.	35,180	9,499
Wildlife Habitat Development	Ac.	27	810
Livestock Exclusion	Ac.	5,338	21,352
Improved Forestry Practices	Ac.	3,038	3,038
Sustained Yield Practices	Ac.	20	20
Cultural Practices	Ac.	27	540
Forestation (Planting)	Ac.	130	3,900
Fire Control	Ac.	8,038	20,497
TOTAL			182,760

1/ At the time of the Work Plan Preparation

2/ Price Base 1964

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Buffalo Creek Watershed, Ohio

(Dollars) 1/

Structure Site No. or Name	Installation Cost - P.L. 566 Funds				Installation Cost - Other Funds					
		Instal. Services		Total			Other			
	Construction	Engineering	Other	P.L. 566	Construction	Installation Services	Adm. of Contracts	Land Easements & R/W	Total Other	Total Inst. Cost
FWRS No. 2	160,947	40,237	11,266	212,450			4,828	79,430	84,258	296,708
					(10,075) 2/	(1,008) 2/			(11,083) 2/	
No. 3	63,396	16,483	4,438	84,317			1,902	29,420	31,322	115,639
Subtotal	224,343	56,720	15,704	296,767			6,730	108,850	115,580	412,347
MULTIPLE PURPOSE NO.1										
3/	58,682	13,252	6,113	78,047	28,642	9,452	2,620	33,200	73,914	151,961
4/					17,000	3,400	1,000		21,400	21,400
Subtotal	58,682	13,252	6,113	78,047	45,642	12,852	3,620	33,200	95,314	173,361
CHANNEL IMPROVEMENT	262,909	65,727	15,775	344,411			7,887	33,142	41,029	385,440
GRAND TOTAL	545,934	135,699	37,592	719,225	45,642	12,852	18,237	175,192	251,923	971,148

1/ Price Base 1964.
2/ Non-project cost for additional top width to be used as roadway for route 285.
3/ Joint Installation Costs.
4/ Water Supply Appurtenances. Includes water intake tower, valves and pipelines under dam.

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Buffalo Creek Watershed, Ohio

(Dollars) 1/

Item	Purpose: Flood Prevention	Purpose: Water Supply	Total
	COST ALLOCATION		
Single Purpose			
Floodwater Retarding	412,347		412,347
Channel Improvement	385,440		385,440
Multiple Purpose			
Floodwater Retarding Water Supply	102,118	49,843	151,961
Water Supply Appurtenances		21,400	21,400
TOTAL	899,905	71,243	971,148
	COST SHARING		
P. L. 566	719,225		719,225
Other	180,680	71,243	251,923
TOTAL	899,905	71,243	971,148

1/ Price Base 1964

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES AND WATER SUPPLY RESERVOIRS

Buffalo Creek Watershed, Ohio

ITEM	UNIT	STRUCTURE NUMBER 1	2	3	TOTAL
Drainage Area	Sq.Miles		12.54		
Controlled	Sq.Miles		3.34		
Uncontrolled	Sq.Miles	3.34	9.20	6.20	18.74
Storage Capacity					
Total Sediment 1/	Ac. Ft.	182	717	539	1,438
Conservation Pool 2/	Ac. Ft.		(350)	(247)	
Flood Water	Ac. Ft.	366	1,000	691	2,057
Between High & Low Stages	Ac. Ft.	(189)	(550)	(351)	
Water Supply	Ac. Ft.	267 4/			267
Total	Ac. Ft.	753	1,717	1,230	3,700
Surface Area					
Conservation Pool 2/	Acres		57	40	
Floodwater Pool	Acres	65	192	128	385
Water Supply Pool	Acres	47			47
Elevations					
Top of Dam	Ft.	909.0	878.5	861.0	
Crest of Emergency Spillway	Ft.	901.5	5/	855.5	
Crest Principal Spillway					
High Stage	Ft.	898.6	861.0	852.5	
Low Stage	Ft.	895.0	852.0	843.5	
Max. Height of Dam	Ft.	35.8	37.0	32.0	
Volume of Fill	Cu.Yds.	78,283	120,612	59,500	258,395
Principal Spillway					
Design Storm Duration	Hrs.	6	6	6	
Design Storm Rainfall	Inch	3.65	3.65	3.65	
Runoff Curve No. (AMC II)		77	78	77	
Storm Runoff (AMC II½)	Inch	2.15	2.22	2.15	
Capacity (low stage)	c.f.s.	27	126	70	
Capacity (high stage)	c.f.s.	107	515	154	
% Chance of Use, High Stage		20	20	20	
Time of Concentration	Hrs.	0.8	1.8	1.1	

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES AND WATER SUPPLY RESERVOIRS

Buffalo Creek Watershed, Ohio

ITEM	UNIT	STRUCTURE NUMBER 1	2	3
Emergency Spillway				
Type		Earth	5/	Earth
Bottom Width	Ft.	60		100
% Chance of Use		2		2
Emergency Spillway Hydrograph				
Storm Rainfall (6 hr.)	Inches	6.70	6.70	5.30
Storm Runoff (AMC II)	Inches	4.09	4.22	2.87
Velocity of flow (V_c) 3/	Ft/Sec	7.3		4.8
Discharge Rate	c.f.s.	787		343
Max. W. S. Elev. 3/	Ft.	904.5		856.9
Freeboard Hydrograph				
Storm Rainfall (6-hr.)	Inches	12.90	12.90	9.80
Storm Runoff (AMC II)	Inches	9.90	10.05	6.94
Velocity of Flow (V_c) 3/	Ft/Sec	12.5	27.7	9.9
Discharge Rate	c.f.s.	3,978	1,995	3,331
Max. W. S. Elev. 3/	Ft.	909.0	878.5	860.7
Capacity Equivalents				
Sediment Volume 1/	Inches	1.02	1.46	1.63
Water Supply Volume 4/	Inches	1.50		
Detention Volume	Inches	2.05	2.04	2.09
Spillway Storage	Inches	3.12	9.00	2.87
Class of Structure		b	b	a

1/ Accumulation volume for 100 years.
2/ 50-year sediment storage.
3/ Maximum during passage of hydrograph.
4/ Water Supply for Sarahsville.
5/ Emergency spillway and freeboard hydrograph routed through twin 4'x9' principal spillway conduits.

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TABLE 3B - STRUCTURE DATA

CHANNELS

Buffalo Creek Watershed, Ohio

Channel Designation	Sta. for Reach Sta.	to Sta.	Watershed Area	Types [1/] of Impr.	Req'd. Channel Capacity	"n" Value	Hydr. Grad. Slope	Bottom Grade	Des. Chnl. Area	Ave. Design Depth	Bot. Width	Side Slopes	Design Vel. in Channel	Volume of Excavation
			Sq.Mi.		c.f.s.		Ft/Ft	%		Sq.Ft.	Ft.		Ft/Sec	1000 cu.yds.
Buffalo Creek														
	306+70	423+00	22.94	C.E.	1050	0.0350	0.00145	0.145	250	6.6	18	3:1	4.18	85.1
	423+00	435+00	23.00	C.E.	1050	0.0350	0.00125	0.125	273	7.0	18	3:1	4.00	14.3
	435+00	488+40	25.51	C.E.	1200	0.0350	0.00125	0.125	301	7.0	22	3:1	4.09	46.2
	488+40	540+00	32.96	C.E.	1330	0.0325	0.00100	0.100	329	7.0	26	3:1	4.07	48.3
	540+00	585+00	36.50	C.E.	1570	0.0300	0.00090	0.090	371	7.0	32	3:1	4.27	72.5
	585+00	708+80	43.27	C.E.	1960	0.0300	0.00075	0.075	469	7.5	40	3:1	4.16	162.8
	708+80	764+10	50.23	C.E.	2520	0.0300	0.00075	0.100	530	8.2	40	3:1	4.37	79.0

1/ C.E. - Common Excavation

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TABLE 4 - ANNUAL COSTS

Buffalo Creek Watershed, Ohio

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost	Total
One Unit:			
Floodwater Retarding Structures (2)	13,508	530	14,038
Multiple Purpose Structure (1)	5,679	250	5,929
8.7 Miles of Channel Improvement	12,627	3,640	16,267
TOTAL	31,814	4,420	36,234

1/ Long-term projected prices.

2/ Price base 1964 amortized at 3 1/8 per cent interest for 100 years.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Buffalo Creek Watershed, Ohio

(Dollars) 1/

Item	Estimated Average Annual Damage Without Project	Estimated Average Annual Damage With Project	Damage Reduction Benefit 2/
Floodwater			
Crop and Pasture	25,403	5,057	20,346
Other Agricultural	1,124	335	789
Nonagricultural			
Transportation	3,650	1,073	2,577
Urban	490	297	193
Subtotal	30,667	6,762	23,905
Indirect	3,101	816	2,285
TOTAL	33,768	7,578	26,190

1/ Price Base - Projected Long-Term

2/ Includes Flood Damage Reduction Benefits of $921. for Land Treatment Measures.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Buffalo Creek Watershed, Ohio

(Dollars) 1/

Evaluation Unit	Average Annual Benefits									Average Annual Cost	Benefit Cost Radio
	Damage Reduction	More Intensive Use	Changed Land Use Agr.	Savings in Bridge Costs	Incidental Recreation	Municipal Water Supply	Redevelopment	Secondary	Total		
One Unit:	25,269	7,523	584	554	7,961	2,334	2,040	4,407	50,672	36,234	
Floodwater Retarding Structures (2)											
Multiple Purpose Structures											
Municipal Water Supply (1)											
Channel Improvement (8.7 Mi.)											
GRAND TOTAL	25,269 2/	7,523	584	554	7,961	2,334	2,040	4,407	50,672	36,234	1.4:1.0

1/ Price Base 1964 for Installation Costs and Projected Long-Term for Benefits and O & M Costs.

2/ In addition, Land Treatment Measures will provide Annual Flood Damage Reduction Benefits of $921.

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INVESTIGATION AND ANALYSIS

The Soil Conservation Service, in assisting the sponsoring local organizations, employed the following data, sources, methods and procedures in the preparation of this plan.

Standard methods and information contained in prepared handbooks, are referred to by name rather than described here.

LAND USE AND TREATMENT NEEDS

Land use and treatment programs proposed in this watershed were planned jointly by the Boards of Supervisors of the Guernsey and Noble Soil and Water Conservation Districts. Technical assistance was provided by the U. S. Soil Sonservation Service, U. S. Forest Service, and the Ohio Division of Forestry.

The Conservation Needs Inventory and basic farm plans within the watershed were used to arrive at the present land use and total conservation needs as outlined in AN-W 748 and supplements. The U. S. Forest Service and the Ohio Division of Forestry made a detailed study of the woodland aspects to determine the woodland needs and amounts of forestry practices to be applied.

The above data were used by the Boards of Supervisors in determining land treatment needs to be met during the project period.

HYDROLOGIC AND HYDRAULIC INVESTIGATIONS

The following physical data and procedures were used for the design of the proposed structural measures and to determine their effect in reducing present floodwater damages. The procedures used, if not referenced, are described in the Soil Conservation Service National Engineering Handbook, Section 4, Hydrology.

Floodwater Damage Evaluation:

Hydrologic Studies - Rainfall-frequency curves for the watershed were developed using data and methods described in the U. S. Weather Bureau Technical Paper No. 40 for 6-hour and 12-hour duration storms. There are no stream gaging stations with adequate records or similar flood peak producing characteristics located within or near the watershed to use in predicting frequency of discharge occurrences.

The unpublished short term record of a stage recorder at the State Route 313 crossing over Wills Creek near Derwent was analyzed. This gage located 1½ miles downstream from Pleasant City has been in operation since 1955 and has about 152 square miles of uncontrolled drainage area plus the Senecaville Reservoir above it. The gage record was used primarily to determine the back water conditions affecting Buffalo Creek.

The hydrologic curve number for the watershed was developed utilizing land use estimates, provided by the Work Unit Conservationist, and hydrologic soil groups from soil surveys. The runoff-

frequency curve for non-agricultural damage evaluation was obtained by use of this curve number and the annual rainfall-frequency curve. A growing season discharge-frequency relation was obtained from gaged records in other watersheds. The growing season runoff-frequency curves for agricultural damage evaluations were developed using this data.

The discharge-runoff relationships for the watershed were obtained by flood routing. In the headwater or tributary reaches, flood routing was based on Soil Conservation Service Central Technical Unit hydrograph peak discharges developed from time of concentration relationships. The Wilson graphical method was used for the stream flood routing through the four downstream main channel reaches.

In the Wilson graphical method, bank-full velocities were developed to determine routing reach travel time. Triangular sub-watershed hydrographs were routed and combined progressing downstream. At Pleasant City triangular hydrographs were developed for both Buffalo Creek (50.2 sq. mi.) and Buffalo Fork (71.6 sq. mi.), which combine to form Wills Creek.

The following flood routings were carried out:

1. Natural (present) conditions: 2 and 25-year growing season frequency.
2. Modified (with project) condition including land treatment, floodwater retarding structures and channel improvements: 5 and 25-year growing season frequency.

In the modified condition routings, the sub-area hydrographs were adjusted to reflect the area under control by the structures. Reach travel times were recomputed using revised bank-full velocities from the channel improvements.

In order to relate discharge to frequency, curves were plotted for each reach showing the relation to routed peak flows (natural and modified) and runoff in inches.

Hydraulic Studies - Engineering field surveys, tied to mean sea level datum, consisted of 11 valley sections, 27 additional channel sections, and 11 bridge and road sections. About 46 high-water marks of the March and June 1963 floods and 8 of the 1913, 1935 and 1937 floods were obtained. Additional engineering data were obtained from photogrammetric topographic maps of the proposed location of Interstate Route 77, and new $7\frac{1}{2}$ min. U. S. Geological Survey topographic maps.

Consultants for the Ohio Department of Highways furnished preliminary construction plans for the embankment and channel relocation being designed for Interstate Route 77. This information was used in the natural condition so that the evaluation would reflect the effects of the proposed structural measures with the proposed road in place.

Discharge rating curves were prepared at the valley cross sections by the development of water surface profiles under natural and modified conditions. Water surface profiles were developed in the natural condition by the Leac h step method for Buffalo Creek from the back water on Wills Creek near Derwent to the junction of South Fork near Sarahsville, and for the laterals North Fork and Little Buffalo Creek. The high-water marks served as checks on the method. In the modified condition the Leach step method of water surface profiles reflects the improved channel capacity in the discharge rating curves from Pleasant City to Sarahsville due to the planned improvements.

The natural condition back water from Wills Creek was computed from an unofficial discharge rating curve at the gage on a c.s.m. basis. The recorder charts indicated that Buffalo Creek and Buffalo Fork had similar time to peaks in revent uniform floods. In the modified condition the change in time to peak on Buffalo Creek and its corresponding state on Wills Creek were considered in the back water calculations.

Elevation-acres flooded curves were developed from the natural condition water surface profiles in each reach using valley section overbank top widths and representative lengths. Adjustment factors, to correlate computed with actual flooded area, were determined from the high-water marks and U.S.G.S. topographic maps. The acres flooded for each reach were related to the elevations of a key section within the reach. Using the stage-discharge curve for this section and the runoff-frequency-discharge relationship for the reach, frequency-acres flooded data were tabulated. The resultant area and depths inundated for selected growing season and annual frequency storms were calculated for both natural and modified conditions to use in the evaluation of the works of improvement.

Structural Measures Design Hydrologic Criteria:

Floodwater Retarding Structures - For the principal spillway design, the 6-hour design storm rainfall amounts were obtained from the U. S. Weather Bureau Technical Paper No. 40 for this watershed. The low stage spillways were designed on a 5-year rainfall to give greater agricultural protection for the more frequent storms. The high stages were designed for 50-year rainfalls. Depth-duration curves, following the method given in Soil Conservation Service Technical Release No. 10, were used as checks on the structures. This was to insure that longer duration storms would not cause the emergency spillways to operate more frequently than desired.

Individual runoff curve numbers were developed for each of the structure sites by a detailed evaluation of their hydrologic soil cover conditions. Future land use changes were used in the development of the curve numbers to determine the runoff from the design storm rainfall. These curve numbers are suitable for final structure design.

Release rates for the low stage spillways range from 8 to 12 cubic feet per second per square mile depending primarily on location within the watershed and on drainage area size. These accumulated discharges were checked in the main damage areas to assure that they will not impair drainage flow. High stage release rates were checked to be sure that bank full channel capacities were not exceeded below the individual structures.

Design storm rainfall criteria for the emergency spillway and freeboard hydrographs were obtained from figures 21.5 - 21.9[1/]. These criteria are based upon 6-hour 100-year frequency and 6-hour maximum probable precipitation maps from U. S. Weather Bureau Technical Paper No. 40. Design hydrographs for the detailed flood routing of the structure sites were computed by the Soil Conservation Service Central Technical Unit method.

Channels - The same runoff-frequency procedures developed in the floodwater damage evaluation were used to determine the discharge-frequency for design of the channel improvements. The channel design discharges were developed by flood routing the 5-year growing season design storm discharge, modified by the retarding structures, through the proposed channel improvements. The design discharge in the lower, Pleasant City, reach was computed assuming the worst condition, that of no tail water. Below the termination of the proposed channel improvement on Buffalo Creek, the modified design discharges were combined with Buffalo Fork to approach the natural condition on Wills Creek.

GEOLOGIC INVESTIGATIONS

Upland Erosion Investigations:

Conservation survey maps, photos, farm plans and field observation of the land areas above structures and intervening areas were used to determine the representative soils, slopes, erosion and vegetative cover in the watershed. The present erosion rate was found to be moderate with 6 per cent of the sloping farm lands having severe erosion.

Gullying in the upland was not found to be a major problem. Several gullies observed during field observations were found to be partially stabilized.

Estimates, using aerial photos and field checks, were made of road bank and channel erosion above all floodwater retarding structures. Channel erosion in the tributaries was found to be moderate for the most part, and severe in some reaches of extensive cropland. Stream migration near the sites is proceeding at a rate of 0.15-0.20 feet per year at the sharp meanders.

1/ Soil Conservation Service National Engineering Handbook, Sec. 4, Hydrology, Supplement A (Revised).

Aerial photos, farm plans and field observation of the status of the cropland and permanent vegetative cover were used to evaluate sheet erosion above all impounding structures. Land characteristics relative to the delivery of the products of erosion were observed.

Sediment from all sources, that will be delivered to each structure site under present and future conditions was calculated. Sediment storage requirements were determined in accordance with the Soil Conservation Service Engineering Memo #16 and Technical Release #12. Measured reservoirs in the general vicinity were used for comparison. The sediment storage figures shown in Table 3 will be used for final design.

Lowland Erosion Investigations:

Aerial photos were the guide to field observation of the flood plain in determining the extent of scour and channel erosion. Portions of all reaches were examined. Farmers were consulted regarding the several scour areas as relating to crop yield differences. The main stem channel is wooded over the greatest part of its length. Many old meanders and oxbows are thickly wooded. Reaches of previously straightened channel were found to have been cleared and to be sloughing actively. Several meanders with cleared banks were found to be migrating.

Most of the channel bank soils are silts and clays and the eroded soils are carried through the watershed. Overwash of suspended fines on the flood plain during out-of-bank flows was checked in the field by hand auger and was found to be imperceptible. Visible deposits were found in some oxbows (abandoned meanders) immediately below cleared channel bank reaches. These deposits are not infertile where they occur. Occasional reduction in crop quality does occur, however, from the deposition of thin films of fine sediment on bottomland crops during overland flood flows.

No significant build-up of natural levees was observed, and swamping from this source or channel filling are not problems.

Structure Site Investigations:

Of seven possible structure sites located on the topographic map three were found to be feasible from, hydrologic, economic and geologic aspects. Preliminary site studies for work plan purposes were made. Geologic information, surficial observation, and limited hand auger borings were used to arrive at the pertinent physical data for engineering purposes, and which are itemized below for each site:

Site #1

Borings on the right and left abutments revealed soft, thinly bedded clay shales at 6.4 feet from the surface, and thinly bedded shaley sandstone at 5.5 feet from the surface respectively. The eroded surface of the sandstone was found to be 5 feet below the channel bottom located against the left abutment which has a vertical wall of exposed rock to a height of 8 feet.

The rock floor across the valley is approximately 7.4 feet below the surface of the alluvium of CL (silty clay) texture.

Two emergency spillway locations were investigated and found that the location on the right upland between the road and the end of the fill will entail little or no hard rock excavation.

Ample borrow was located in the emergency spillway area, the right upstream valley side, the left upland, as well as the alluvial cohesives in the valley bottom if used selectively. The left upland is cut up by drainage ways and has numerous slips.

Rock excavation for a core trench and abutment preparation can be done by common excavation. No stability or permeability problems are anticipated.

There is a possibility, according to local sources of information that strip mine operations may be extended in this subwatershed. A detailed subsurface investigation will be needed to determine irregularities in the valley bottom rock floor.

<u>Site #2</u>

Borings in both abutments showed that interbedded sandstone and shale occur at $1\frac{1}{2}$-4 feet below the surface. The left abutment is very steep, and the right abutment somewhat less steep. The entire fill site is wooded.

The valley bottom was found to be moist to wet to 2 feet where heavier CL materials were encountered. The surface 0.6-1 ft. are highly organic silts with a watertable at 2 ft. on 5/7/64. No rock was encountered to 10 ft. in the valley bottom.

The principal spillway will be based on CL materials. It is anticipated at this time that the rock floor is too deep upon which to base the spillway and conduit. A core trench can be installed in unconsolidated materials across the valley bottom; however, removal of regolithic rock will be needed in both abutments for positive cut-off. This can be done by common excavation.

The investigation for an emergency spillway location showed the left upland not to be feasible because of the elevation, steepness, and preponderence of rock removal needed. The right upland is somewhat less steep but rock-bound, and would entail an estimated 90 per cent rock removal including some required blasting. As planned, at present, no emergency will be installed, and the design of the mechanical spillway will be such as to serve both purposes.

Borrow material from upland sources is scarce or remote but of acceptable quality. Additional borrow is available from the CL reservoir bottom and colluvial valley sides.

Most of the valley fill is impermeable and no water loss problem is anticipated. Stability for a relatively low but long fill is good, however, a detailed subsurface investigation will be needed particularly to determine the foundation conditions for the mechanical spillway and extent of borrow materials.

Some pre-construction drainage may be needed to dry out the fill site and particularly if borrowing should be done in the valley bottom.

Site #3

No rock was found to 10 ft. in the abutments. Tie-in of the fill to good silty clay materials can be achieved without problems. No seeps were encountered in this area.

The valley bottom is predominantly silty clay material with no apparent soil, rock or water problems as indicated within the limited scope of this preliminary investigation.

It appears that the emergency excavation will be confined to unconsolidated CL materials. No rock was encountered to 10 ft.

Borrow of good quality is ample and can be taken from the emergency cut, the left upland, and the upstream reservoir bottom if necessary.

This is a good site physically with no anticipated rock or water problems. A detailed investigation during operations will be needed to determine foundation conditions for the principal spillway and fill stability analyses.

Channel Investigations:

Numerous meander cut-offs are planned in the channel improvement project in this watershed. The proposed cut-offs were grouped into investigational reaches - the total covering sections of the channel from Sarahsville to Pleasant City. Hand auger soil borings were made to 2 ft. below the present channel bottom except in several high points where the borings were carried to 5 ft. below the present channel bottom.

The soil profiles encountered throughout the length of the proposed improvement are uniform and reflect the widespread alluviation involving a complexity of changes and states resulting from effects of glaciation just to the north.

No stratification was found although the bank profiles contain dispersed materials. The soils range from clayey silts in the plow layer to subsoils of light silty clays to the extent of the borings. Very little change was noted from one boring to another except variations in grittiness and the inclusions of small rock fragments. Because of the dispersed and silty textural combinations of these soils the banks will be unstable if left too steep which induces undercutting and sloughing during high flow stages. Most treeless

banks in previously improved straight reaches are actively eroding under present flow conditions.

Two areas included in the improvement reaches were found to contain residual rock of the Pennsylvanian Conemaugh formation in the sides and bottom as follows:

1 - A very recent cut through a low rock upland spur into the valley was made by blasting and is located on the Watson farm $1\frac{1}{4}$ miles north of Sarahsville. A check should be made for adequate capacity.

2 - A meander hits the main valley wall and is deflected to the north by the rock structure in this upland. This meander curve is stable and any improvement will be in the rock-free alluvium on the bottomlands. This is located just below the covered bridge on the side road leading to Mt. Ephriam.

In view of the somewhat dispersed and silty nature of the upper horizons of the channel bank profiles it appears that 3:1 vegetated side slopes would be preferred. No less than $2\frac{1}{2}$:1 should be used under the flow velocities expected with the project installed. These interpretations have been made on the basis of the soils examined and the observation of the behavior of these soils under field conditions in the improved reaches (shrinkage, freeze-thaw, trampling, etc.).

DESIGN ANALYSES FOR STRUCTURAL MEASURES

Design Standards and Procedures for Retarding Structures:

Designs for the floodwater retarding structures and the floodwater retarding aspects of the multiple purpose structure are based upon criteria as established in Soil Conservation Engineering Memoranda 16, 27, 31, 40, 42, 43 and 47, and Technical Releases 2 and 10.

Cross-section surveys were made along the proposed centerlines of fill and in the impoundment areas of the structure. Profile surveys were also made at the lower elevations in the impoundment areas to determine the extent of road and building inundation. All elevations were tied into mean sea level datum. U. S. Geological Survey $7\frac{1}{2}$-minute quadrangle topographic maps and aerial photographs were used extensively.

In developing the area-capacity curves, U. S. Geological Survey topographic maps were checked with the cross-section survey data noted above.

All the floodwater retarding structures were designed with 100-year sediment storage. A permanent wet conservation pool is planned at the 50-year sediment level except at structure No. 1 which contains, in addition, the water supply volume. The flood routings

were started at the elevation for the 100-year sediment volume at sites 2 and 3. At water supply site No. 1 flood routings were started at permanent pool elevations.

In the design of the structures for floodwater storage the following crieria were used:

1. A port in the principal spillway riser set at the permanent pool elevation to control the normal lake elevation for 5-year runoff volume with antecedent moisture condition II½.

2. A high stage opening in the principal spillway at the top of the 5-year frequency design storage or two feet above the low stage port whichever is greater.

3. An emergency spillway crest set at or above (a) the peak of maximum flood storage required for the principal spillway design frequency runoff with antecedent moisture condition II½ or (b) two feet of minimum stage above the crest of the crest of the high stage riser, whichever is greater.

4. Freeboard and emergency spillway dimension to be determined by flood routing the freeboard and emergency spillway hydrographs respectively.

The principal spillway design storms were flood routed by the Beta method except structure No. 1 which was routed by the storage-indication method. Technical Release No. 10 procedure was used. The emergency spillway and freeboard design hydrographs were routed by the storage indication method.

For estimating costs, the structure design was based on side slopes of the dams being 2½:1 downstream and 3:1 upstream and minimum top width of fill being 14 feet. Berms of 8-foot width were used on structures 2 and 3. These dimensions may change in final design following recommendation of the Soil Mechanics Laboratory.

Structure No. 1 which is planned as a flood prevention-water supply multiple purpose structure utilizes a conventional type principal spillway as shown in Figure 1 with a flat top inlet and reinforced concrete pipe conduit. No berm is planned except around the inlet but protection of dumped stone riprap is provided from the point of maximum drawdown to a few feet above the low-stage inlet. Alternate studies were made in determining the dimension of the emergency spillway.

Structure No. 2 has several design problems and several alternate studies were made. Because of massive sandstone and steep high slopes on the abutments, the structure was designed without an emergency spillway around the side. Instead, the freeboard hydrograph was flood routed through the concrete spillway which is planned as twin 4 x 9 feet conduits with an inlet having a weir length of 56 feet and a SAF type stilling basin at the outlet. Relocation of a state highway across the top of the fill has been planned. This necessitates the widening of the fill from 14-foot top width to 28 feet and the lengthening of the conduit by 14 feet.

Structures No. 1 and 2 were planned in series. Engineering Memorandum SCS-43, "Design Criteria for Water Storage and Water Retarding Structures in Series", was used to design the lower structure (No. 2). The design was based on storm flows from the uncontrolled area plus outflow from Structure No. 1 routed through the intervening area.

Design Standards and Procedures for Channel Improvement:

Soil Conservation Service "Standards and Specifications for Open Ditches" in Ohio, National Engineering Handbook 16 (Drainage) and pertinent engineering memoranda were used as criteria and guides for the design of channel works of improvement.

Field surveys made by Soil Conservation personnel and other field data from U. S. Geological Survey, Ohio Department of Highways, and aerial photographs were used. These data, which were used to develop the profiles for channel design and cross sections for quantity determinations, are described in the "Hydrologic and Hydraulic Investigations" section of this plan.

In design of the channel, the hydraulic gradient was established at average low ground elevation. The required discharges for the level of protection provided by this plan will flow at or below the hydraulic gradient. The planned side slopes meet criteria, and the design velocities are below maximum allowable velocities for the soil types through which the channel flows. Seeded berms and side slopes are planned where there is to be channel excavation. Realignment including several cut-offs is planned reducing the overall length. Approximately 900 feet of channel improvement is planned in cooperation with the Ohio Department of Highways.

ECONOMIC INVESTIGATIONS

General:

Damages and benefits were calculated from basic economic information obtained from various reports and field investigations. Interviews with flood plain operators and local agricultural technicians were made to determine the type, extent and location of agricultural damages. Other data were obtained from urban occupiers as to the magnitude of damages in urban areas. Highway and railroad officials provided transportation damage data.

Damages and benefits were computed at long-term levels by use of indices and projections in the Agricultural Price and Cost Projection Pamphlet, by the Agricultural Research Service and Agricultural Marketing Service, September, 1957.

The costs of planned works of improvement are based on current construction costs for southeastern Ohio. Land, easements, and rights-of-way values were estimated and ranged from $5 to $466 per acre. For lands having 100 per cent loss of present use, costs

were computed for fee simple title acquisition. The costs of lands used for temporary pool areas and channel construction were based on easement values. The estimated economic life of the channel improvement is 50 years, and for the three structures 100 years. Annual installation costs were computed by the application of an interest rate of 3 1/8 per cent for amortization based on the estimated economic life of the respective improvements.

Agricultural Floodwater and Sediment Damage:

Floodwater and sediment damage to crops and pasture constitute the majority of the damages computed as agricultural. Farmer interviews with more than 20 flood plain operators plus consultation with agricultural technicians and correlation with recent crop damage history provided a basis to establish a damageable value per acre for the principal crops in the flood plain area. Loss of expected normal yields, lost production costs and extra tillage operations were taken into account in establishing these damageable values. The season of expected flood occurrence, depth and duration of the flooding waters were correlated and weighed into the over-all damage estimate to obtain a composite-acre damage and stage-damage value for each reach.

Hydrologic data provided area flooded - frequency of occurrence relationships. With this information and composite-acre damage data, existing average annual damages by reaches were computed for the inundated areas.

Utilizing the flood damage-frequency of occurrence relationship for "without" and "with" project installations, it was possible to determine the average annual flood damages prevented. These reductions are considered as benefits to the projects and are summarized in Table 5.

Other agricultural floodwater damages involving farm flood gates, farm buildings, rurban homes, farm lanes, culverts, livestock loss, and debris pickup were obtained by interviews and related data from similar watersheds. The average annual damages "without" and "with" project were computed by use of the stage-damage-frequency relationships.

Urban Floodwater and Sediment Damage:

The town of Pleasant City and the adjacent unincorporated urban area receive overbank-flow damage from Buffalo Creek which flows from south to north along the western boundary of the village. The types of damage and damage values were determined for one industrial and the commercial establishments by interview. The damage values for two of the properties were based on data obtained for similar establishments in an adjacent watershed. Elevations were obtained on all evaluated properties.

The information obtained in this area, when related to hydrologic data, permitted correlation of frequency-stage-damage relationships in the damage computations.

Transportation Facilities Damages:

Public road and bridge floodwater damage data were obtained from local residents, and responsible state, county and township road officials.

These data were used to develop stage-damage relationships per mile of inundated road for use in computing existing annual damages and remaining damages "with" project. The damages prevented constitute the public road transportation benefits. All reaches were separately evaluated for flood water damages to roads.

Railroad flood water damage data were obtained from railroad officials. Damage values were conservatively projected from more detailed data obtained on the same railroad on an adjacent watershed.

These data were used to develop stage-damage relationships per mile of inundated railroad for use in computing existing annual damages and remaining damages "with" project. The damages prevented constitute the railroad benefits.

Indirect Damage:

All indirect damages were estimated as a percentage of direct floodwater and sediment damages. Ten per cent was used for such agricultural losses as the inability to market livestock in a timely manner, market milk, etc.

Indirect damages of 15 per cent were used for losses to commercial and industrial establishments. These include loss of a safe water supply for some time due to the flooding of wells and cisterns commonly used throughout the area, and loss of use of the individual sewage facilities.

Indirect damages resulting from direct damages to public roads, bridges and culverts were estimated at 15 per cent. Excessive travel costs are incurred from re-routing traffic around flooded and washed-out roads. Heavy duty trucks hauling coal from strip mines cause damage to the secondary roads. These roads were not built to withstand heavy traffic. This results in high road maintenance in an area having limited revenues for this purpose. Extra travel and expense is incurred due to the closing of normal bus routes for transporting school children. During flooding many people in the watershed are faced with extra travel and expense to secure needed goods and services, and to get to their place of employment.

Inundated railroad tracks cause train delays of a week or more, disrupting traffic patterns and causing shipping delays and re-routing of cargo. No loss of perishables due to such delays were reported, however, a coal company which ships coal daily on the railroad to a power plant reports it incurs an added expense when forced to

hire trucks to haul its coal. This happened twice in 1963. These indirect damages were evaluated at 25 per cent.

Other Flood Prevention Benefits to Agriculture:

Benefits were based on the reduction in flood stages which will permit greater land utilization. Data and information from farmer interviews, local agricultural technicians, and other sources provided the basis for determining cropping patterns, yields, crop production costs and associated costs "without" and "with" project.

An estimated 227 acres were determined to have productivity restored to former levels. The evaluated benefits were reported as damage reduction benefits.

There are 21 acres subject to changed land use in the additional area provided by the 5-year level of protection.

More intensive use of existing cropland was calculated to occur on 848 acres, the additional area to be protected during a 2 to 5-year flood.

On the above 1,097 acres the monetary benefits were derived from the difference in net returns "without" and "with" project. Allowances were made for added floodwater damage to the higher value crops, the associated costs necessary to produce these crops, and the reduced net income in the upland due to the shifting of crops. The benefits were discounted to provide for the time lag in their accrual. A summary of the benefit evaluation of lands restored to their former productivity, changed land use, and the more intensive use of benefitted land is as follows:

EVALUATION SUMMARY

Without Project:

Land Use	Acres	Flood-Free Yield		Net Return (Dollars) 1/
Corn	680	78	bu.	35,816
Hay	534	2.2	T.	11,652
Pasture	489	86	cpd.	6,040
Other	174			
Total	1,877			53,508

Restoration to Former Productivity with Project:

Land Use	Acres	Flood-Free Yield		Net Return (Dollars) 1/	Differences in Net Return (Dollars) 1/
Corn	795	78	bu.	41,799	5,983
Wheat	112	25	bu.	2,986	2,986
Hay	534	2.2	T	11,652	0
Pasture	262	85	cpd	3,198	-2,842
Other	174				
Total	1,877			59,635	6,127

1/ Price Base, projected long term.

(Continued - next page)

Increased Net Return (Gross Benefit)	6,127
Less Added Flood Damage to Higher Values	128
Less Development Cost (Associated Cost)	1,294
Less Loss In Upland Production of Corn	1,290
Unadjusted Net Return	3,415
Adjusted for Lag in Accrual (Net Benefits)	3,063

Changed Land Use From Low to High Agricultural Use:

Land Use	Acres	Flood-Free Yield		Net Return (Dollars) 1/	Difference in Net Return (Dollars) 1/
Corn	816	75	bu.	42,861	1,062
Wheat	112	25	bu.	2,986	0
Hay	534	2	T	11,652	0
Pasture(Imp.)	7	100	cpd	99	99
Pasture	238	85	cpd	2,899	- 299
Other	170				
Total	1,877			60,497	862

Increased Net Return (Gross Benefit)	862
Less Added Flood Damage to Higher Values	25
Less Development Cost (Associated Cost)	167
Unadjusted for Lag in Accrural (Net Benefit)	670
Adjusted for Lag in Accrual (Net Benefit)	584

After More Intensive Use of Land with Project:

Land Use	Acres	Flood-Free Yield		Net Return (Dollars) 1/	Difference in Net Return (Dollars) 1/
Corn	856	90	bu.	53,905	11,044
Wheat	154	32	bu.	6,034	3,048
Hay	452	3.2	T	15,201	3,549
Impr.Pasture	105	104	cpd	1,547	1,448
Pasture	140	86	cpd	1,717	- 1,182
Other	170				
Total	1,877			78,404	17,907

Increased Net Return (Gross Benefit)	17,907
Less Added Damage to Higher Values	695
Less Development Cost (Associated Cost)	5,365
Unadjusted Increase Net Return	11,847
Adjusted for Lag in Accrual (Net Benefit)	7,523

1/ Price Base, projected long term.

Redevelopment Benefits:

Data for determining benefits from employment stemming from project installation were obtained from engineer's estimates, the Ohio Bureau of Unemployment, and the Ohio Department of Development.

Labor costs involved in the project structural measures were determined with consideration given to wage rates, types and classes of labor. The extent of the unemployed or underemployed was determined for the project area. Applicable data were obtained from experienced contractors showing what portion of their labor costs were spent for local labor. Labor will come primarily from counties designated as Area Redevelopment Areas. The practice of contractors in use of labor and the potential supply of unemployed or underemployed local labor assures reasonableness to the project redevelopment benefits claimed (Table 6).

The labor portion of the average annual operation and maintenance costs for the structural measures was estimated. Evaluations were made, as described above, to determine that portion of the labor costs which will benefit the unemployed and the underemployed.

Secondary Benefits:

Local secondary benefits stemming from the project were evaluated at 10 per cent of the direct primary project benefits.

Secondary benefits occuring outside the project area were not evaluated.

Recreation Benefits:

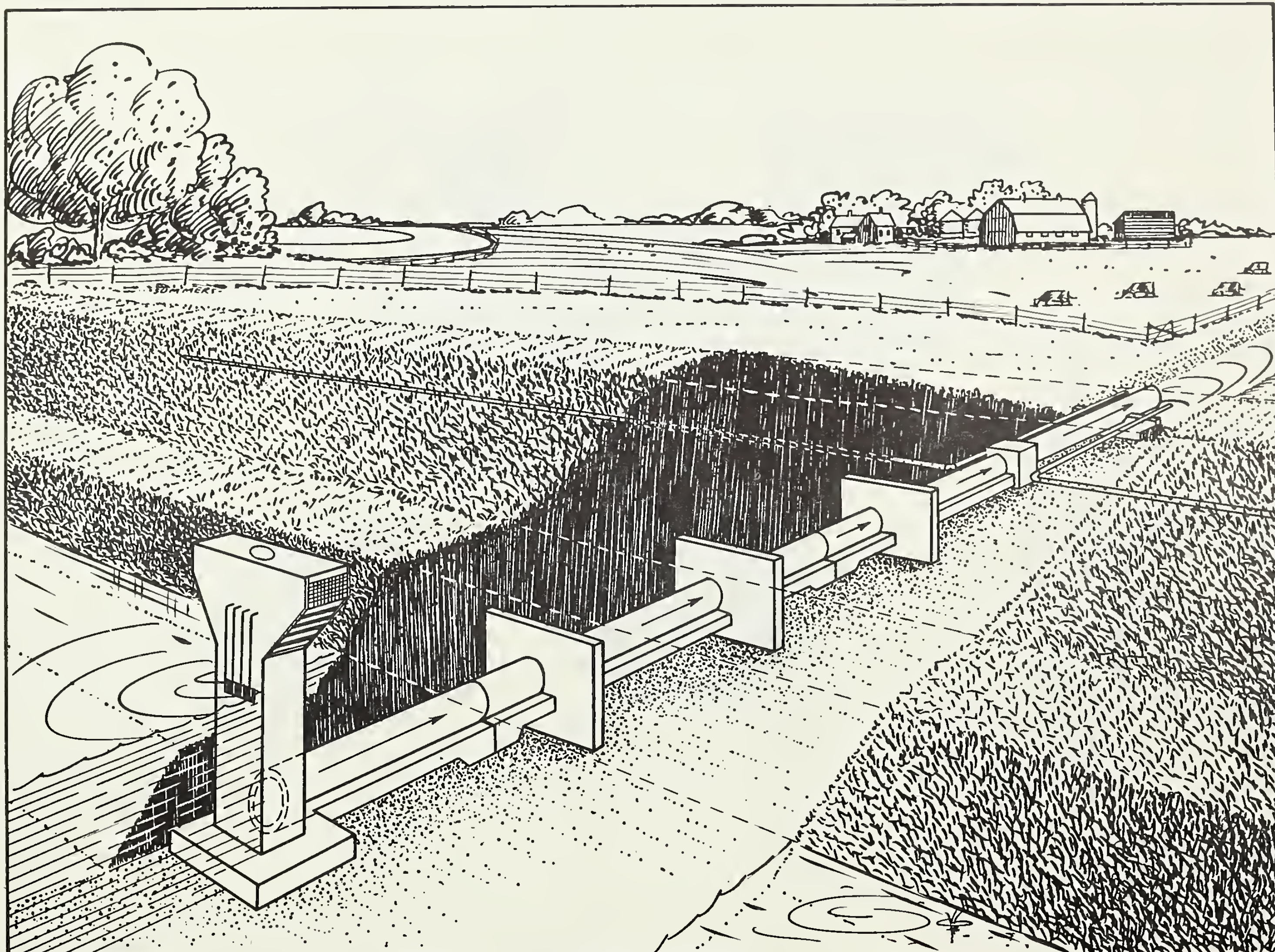
Incidental recreational use of the conservation pool of the three reservoirs was evaluated with appropriate discounting for the development of the aquatic aspects and the future loss of the pool area. A state-wide inventory showing the visitor-day use of similar public recreational areas under state ownership was used as the basis for estimating the visitor-day use.

Water Supply Benefits:

Municipal water supply has been incorporated into the multiple purpose structure No. 1 as shown in the cost allocation. Local interests estimated that the benefits from the non-agricultural water storage were at least equal to the cost of the cheapest alternative source of equivalent water supply. This was the cost of a single purpose-municipal water storage reservoir at each structure site or other suitable location in the general area. The costs were allocated by the Use of Facilities method as shown below in the cost allocation of Structure No. 1.

COST ALLOCATION TO PURPOSE - Site No. 1

Item		Unit	Flood Prevention	Water Supply	Total
Reservoir Capacity		Ac. Ft.	548	267	815
Allocated Joint Costs	(	Percent	67.2	32.8	100.0
	(	Dollar	102,118	49,843	151,961
Specific Costs:					
Water Supply		Dollar		21,400	21,400
Total Allocated Costs		Dollar	102,118	71,243	173,361

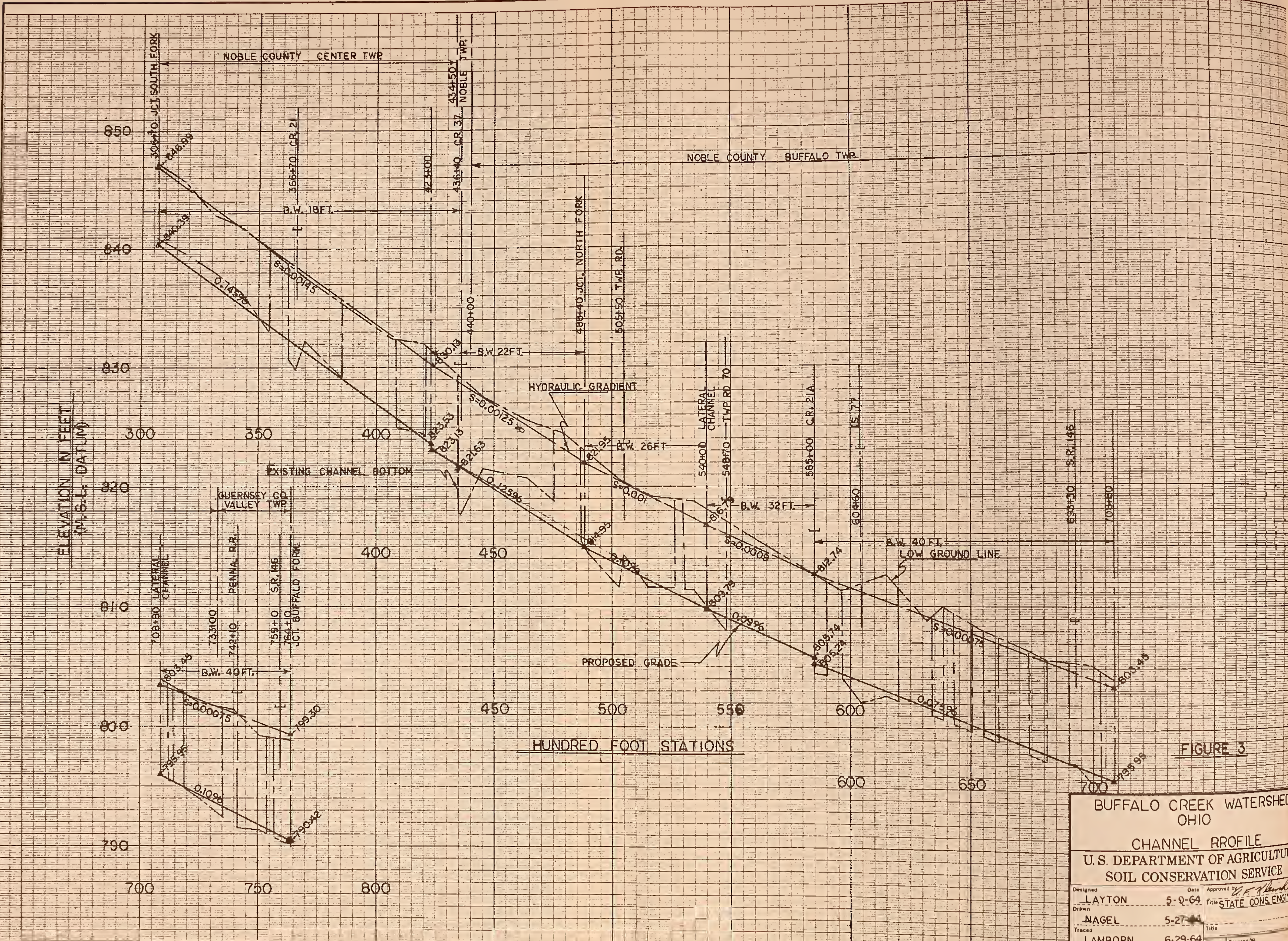


Reinforced concrete pipe with flat top inlet.

FIGURE 1

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



BUFFALO CREEK WATERSHED
OHIO

CHANNEL RROFILE

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed LAYTON	5-9-64	Approved by STATE CONS. ENGINEER
Drawn NAGEL	5-27-64	
Traced LAMBORN	6-29-64	
Checked RICHARDSON	6 29 64	WORK PLAN

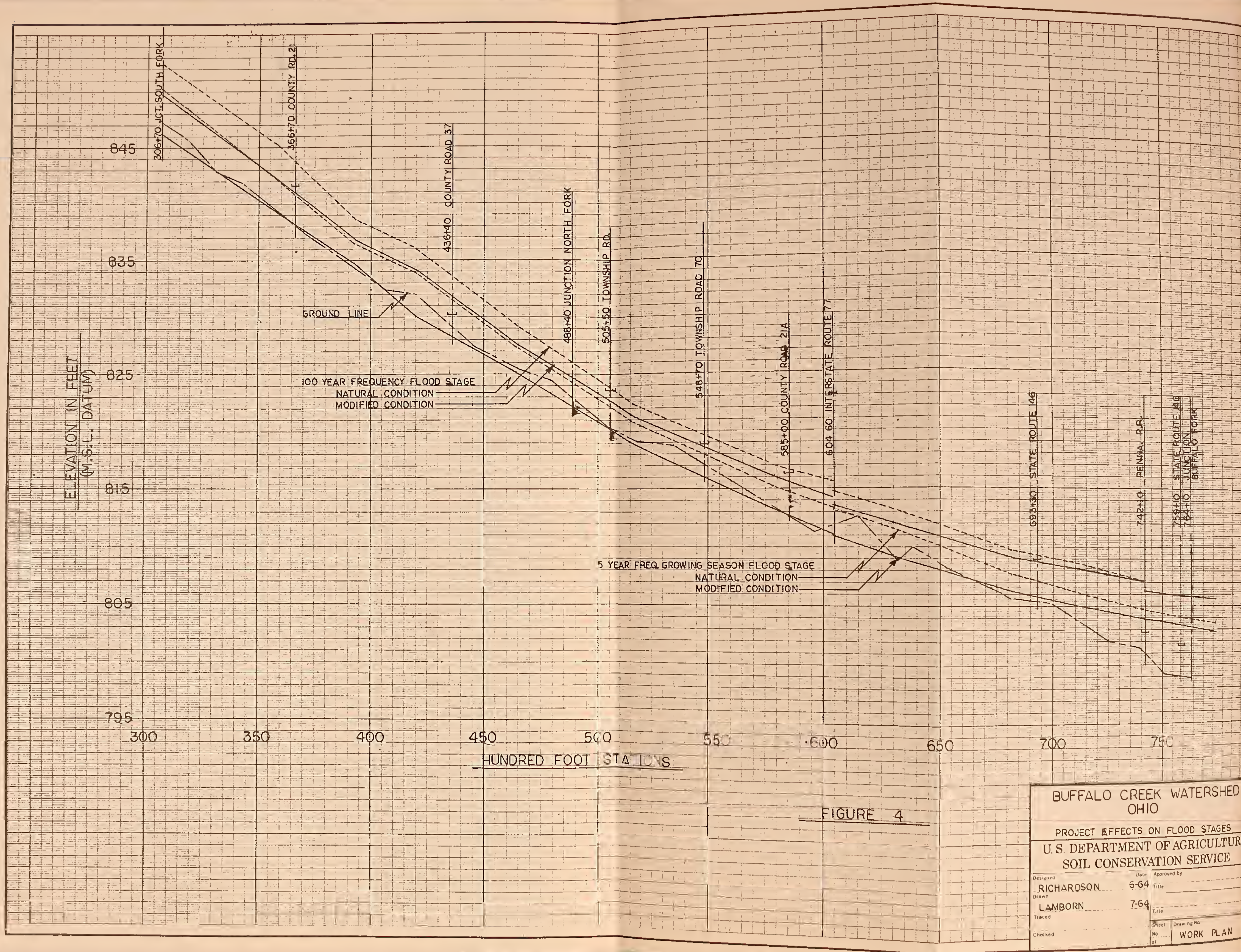

ELEVATION IN FEET
(M.S.L. DATUM)
845
835
825
815
805
795
300
350
400
450
500
550
600
650
700
750
HUNDRED FOOT STATIONS
306+70 JCT. SOUTH FORK
366+70 COUNTY RD. 21
436+40 COUNTY ROAD 37
488+40 JUNCTION NORTH FORK
505+50 TOWNSHIP RD.
548+70 TOWNSHIP ROAD 70
585+00 COUNTY ROAD 21A
604 60 INTERSTATE ROUTE 77
693+30 STATE ROUTE 46
742+10 PENNA. R.R.
759+10 STATE ROUTE 46
764+10 JUNCTION BUFFALO FORK
GROUND LINE
100 YEAR FREQUENCY FLOOD STAGE
NATURAL CONDITION
MODIFIED CONDITION
5 YEAR FREQ. GROWING SEASON FLOOD STAGE
NATURAL CONDITION
MODIFIED CONDITION
BUFFALO CREEK WATERSHED
OHIO
PROJECT EFFECTS ON FLOOD STAGES
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed RICHARDSON 6-64
Drawn LAMBORN 7-64
Traced
Checked
Approved by
WORK PLAN

FIGURE 4

EXHIBIT A

EXCERPTS FROM THE FORESTRY PROGRAM

FOR

BUFFALO CREEK WATERSHED
GUERNSEY AND NOBLE COUNTIES, OHIO

Procedure:

Woodland area locations are based on USGS large scale quadrangles of recent date, adjusted for latest changes in land use.

A cruise was designed establishing ten study plots using random sampling techniques. Sixty observations of hydrologic condition factors were made on these plots.

Timber types, conditions and volumes were observed and determined for each plot. Past treatment and management needs were recorded. The data was summarized, analyzed and developed through standard calculations into the program that follows:

Woodland Condition Summary:

Woodlands cover approximately a fourth of the watershed and are located largely on the steeper slopes, many with thirty to fifty or more percent gradient. They consist of mixed hardwood types including white and red oaks, beech, ash, walnut, tulip poplar, hickory, maple, and other species. Some small scattered pine plantations, usually red or white, have been made.

Presently few woodland areas exist with sufficient timber volume for an operable harvest. Small areas have been logged recently, or could be harvested, but these areas are limited.

Due to changing agricultural practices and the large percentage of rural population who earn a part of their income from other sources, land use is affected. Poorer pasture land is reverting to woodland and cropped land is reverting to pasture. Natural seeding of hardwoods is gradually reclaiming many of these areas. While the more desirable species may not be the first to seed, they will in time come in. The better species, including tulip poplar, reseed naturally on logged areas and openings if a seed source is present.

Fires which once burned over much of the woodland annually have been largely eliminated in the past thirty years. Fire protection is provided by local fire departments and rural residents in cooperation with the Ohio Division of Forestry which provides fire fighting tools. In case fire overhead or special equipment is needed they are provided by the Division of Forestry. The watershed is within Project Area #15, Cooperative Forest Management Program and has a Service Forester assigned.

While most woodlands were once pastured to some degree conditions have changed during the past thirty years. Cattle now use no more than an estimated 30 percent of the woodlands and this will be further reduced. Where fencing is necessary to keep cattle out of woodlands a high degree of interest by operators is indicated. It is anticipated that applied fencing will eliminate more cattle from woodlands with assistance of ACP measures.

Over 50 percent of the woodland, especially on north and east slopes, can be improved by cultural measures. Program requirements reflect the need for the most desirable categories of cultural work. As most farm operations are conducted single handed and the farmer also works away from home, it is difficult to interest many in doing stand improvement work.

Interest in tree planting has been rising steadily in recent years. Individual plantations are small but reflect the interest of many in the need for tree planting. Indications are that this interest level will continue and probably improve but no extensive areas will be planted. Coal mining is very limited on this watershed. Little or no planting will accrue from this source.

Forestry Program for Watershed Protection:

The total need for each practice under the forestry program reflects the present condition of the woodlands. To achieve maximum improvement of the hydrology of the woodland soils it would be necessary to accomplish the entire needed job. During the five-year installation period a portion of this total need will be achieved. This five-year goal is the immediate objective.

Total additional needs for forestry include:

Practice	Acres	Percent of Total Woodland
Livestock Exclusion	2,700	34
Improved Forestry Practices	5,000	62
Sustained Yield Practices	450	6
Cultural Practices	4,500	56
Forestation	130	-

The following described forestry measures are those recommended for use on PL-566 watershed work projects in the North Central Region. The primary purpose of these measures is to improve and maintain the hydrologic condition of watershed woodlands. Installation of forestry measures will simultaneously result in improvement of the timber stand and enhancement of other basic values which are inherent in a well-managed forest. Additional measures may be prescribed and recommended to correct unusual situations on some projects.

Livestock Exclusion:

This measure consists of excluding all farm livestock permanently from woodlands. Fencing all or a part of the woodland may be required. Livestock exclusion also may be accomplished by a permanent change in use of agricultural land adjoining the woodland.

Grazing by livestock has a serious damaging effect on the hydrologic condition of a woodland. The litter and humus layers are destroyed or compacted and this greatly reduces their ability to absorb water and to hold it. As a consequence, the amount of runoff is increased. Grazing also destroys young growth and reduces the density of the stand, thus it impairs the development and replenishment of litter and humus. Damage to both the young growth and mature trees reduces the productivity of the woodland the quality of its forest products.

Technical assistance is needed to point out to woodland owners the harmful effects of woodland grazing from the standpoint of low forage yield. Damages to woodland which result in poor hydrologic condition and reduction of other values are emphasized. A plan is needed to guide the owner in correcting these abuses.

Improved Forestry Practices:

This measure is aimed at improving woodland conditions and securing adequate stocking of desired species and mixed age classes. Stability, sound resource use, and long term considerations are involved. Adequate woodland management plans are a necessity.

The Forest Management Plan recognizes, defines, and schedules fire protection, livestock exclusion, insect and disease protection, species selection, stand composition, thinning, cultural and sanitation work, needed tree planting and interplanting, harvest cutting and other factors. Forest values for watershed protection, wildlife cover, recreation and other selected uses are all considered when the plan is prepared.

Technical forestry assistance is necessary for:

1. Conducting meetings in cooperation with other agencies and making contacts which are necessary for the purpose of educating and motivating woodland owners and operators.

2. Examination of woodlands to obtain stand and growth data and other information needed for preparation of maps and plans.

3. Preparing the Forest Management plan in consultation with the owner and discussing with him in the woods all phases of this plan.

The Forest Management Plan, when implemented, will insure the improvement and maintenance of the hydrologic condition. Ann appreciable improvement in water quality and storage capacity will result. Timber production will also be increased.

Sustained Yield Practices:

This measure includes accomplishment of many of the practices scheduled in the Forest Management Plan as these relate to sustained yield management. They include:

1. Boundary marking, estimating and planning for sale and removal of timber.

2. Marking timber for harvest, locating logging roads, skid trails, landings, and other clearings.

3. Marketing and contract preparation assistance.

4. Inspecting an operation while in progress and after its completion. The timber stand, of course, will be managed to maintain the proper stocking level.

Technical assistance is necessary to plan and conduct the above operation with the landowner with the least possible disturbance to the existing hydrologic condition. Thereafter an improvement of the hydrologic condition of the area will occur.

Cultural Practices:

This practice consists of the conventional timber stand improvement measures and reinforcement planting, with special emphasis on improving the hydrologic condition of the woodland. Diseased, defective, poorly formed and otherwise undesirable trees are eliminated from the stand by cutting, treating with herbicides, or girdling to improve species composition, stand density and rate of growth. At the same time it is important to maintain the proper level of stocking.

Timber stand improvement when properly applied will increase yields and produce higher quality products. It will help to insure that the land will remain in woodland, be managed and protected, thus contributing needed hydrologic benefits.

The stand conversion practice consists of planting trees in openings of thinly stocked woodlands to bring them to the proper stocking level and to improve their composition and hydrologic characteristics. A fully stocked stand of desirable tree species is the objective.

Technical assistance is needed to determine the treatment to apply, methods to use, marking of trees in the stand, selection of tree species to plant, and checking work which has been performed under this practice.

Forestation:

This measure consists of planting suitable species of trees on open land for the establishment of a forest stand. Planting is recommended for land better suited to woodland than to agriculture, that is, land with steep topography, depleted fertility, presence of rocks, brush, erosion, or other factors.

The purpose of the measure is to improve hydrologic conditions by the establishment of a forest cover, and achieve better land use. This will build up litter and humus and create conditions which will contribute to better infiltration, retention and detention capacity, reduced runoff and soil stabilization.

Technical assistance is needed to help the landowner select the area to plant and species and methods to use in planting, to schedule planting equipment, to give assistance during the planting operation, and to check completed projects.

Hydrologic Significance:

Soils in the forested area are predominantly in hydrologic soil group C which is that group having slow infiltration properties after presaturation. (Some plots, however, were located on soils in the B group and the computations have included these. The final figure, therefore, reflects as nearly as possible the hydrologic soil groups present.)

Present hydrologic condition class is 2.6 with a corresponding runoff/precipitation curve No. of 77.1. This indicates a poor hydrologic condition.

Installation of the measures programmed above will bring the average future hydrologic condition during the next 50 years to a class of 3.5 with a corresponding runoff/precipitation curve No. of 70.4. This indicates an average or fair hydrologic condition.